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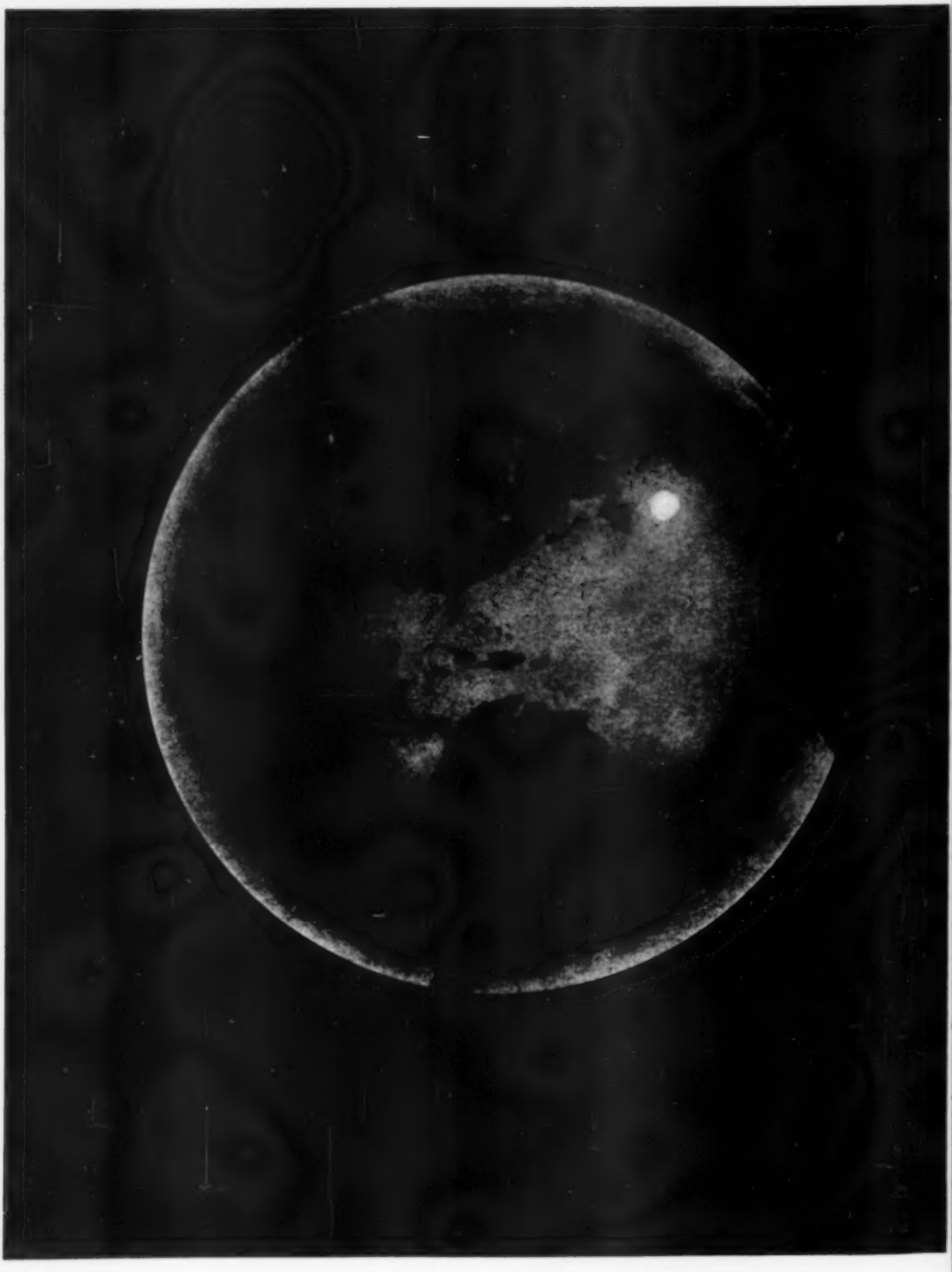

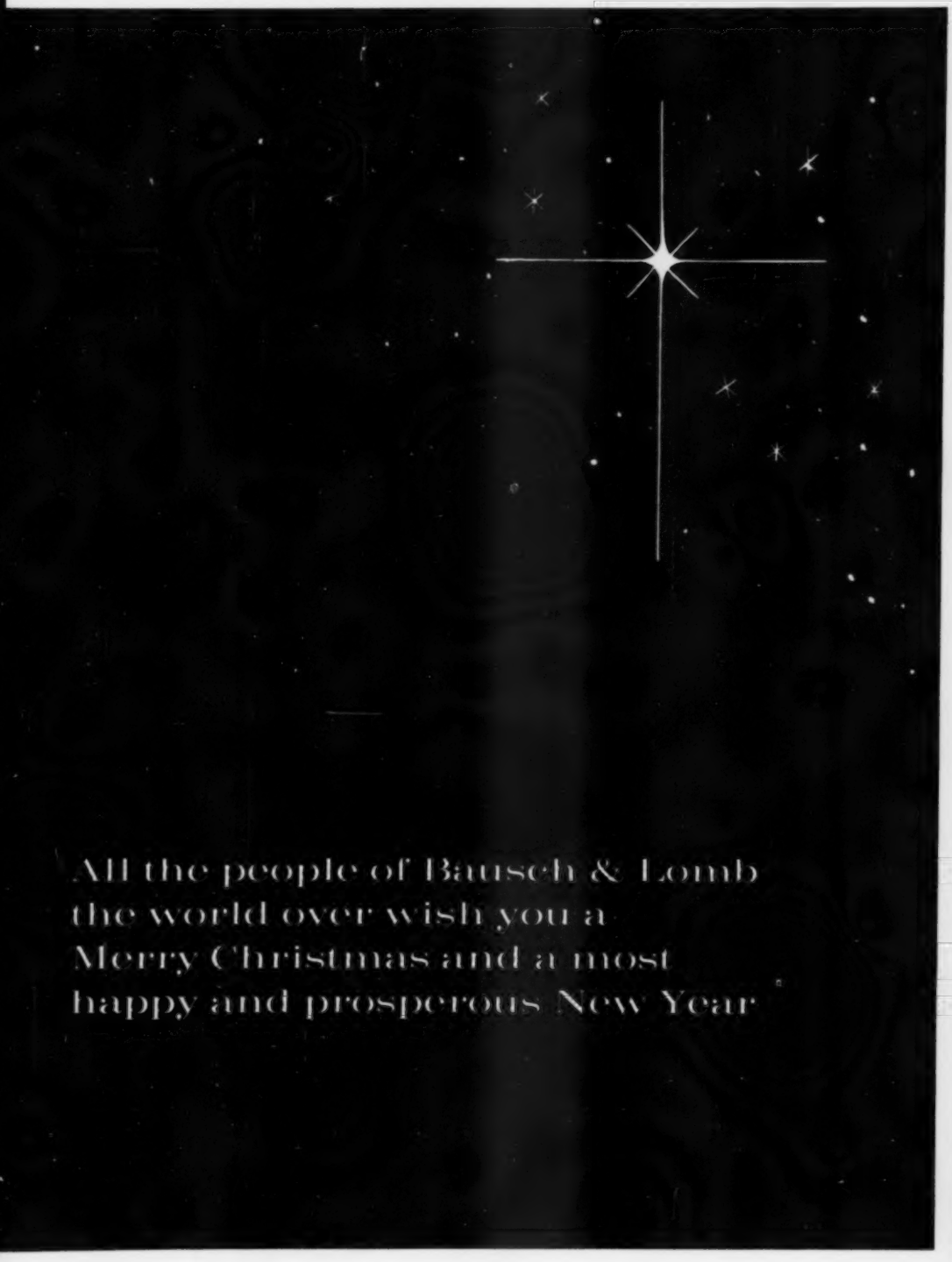
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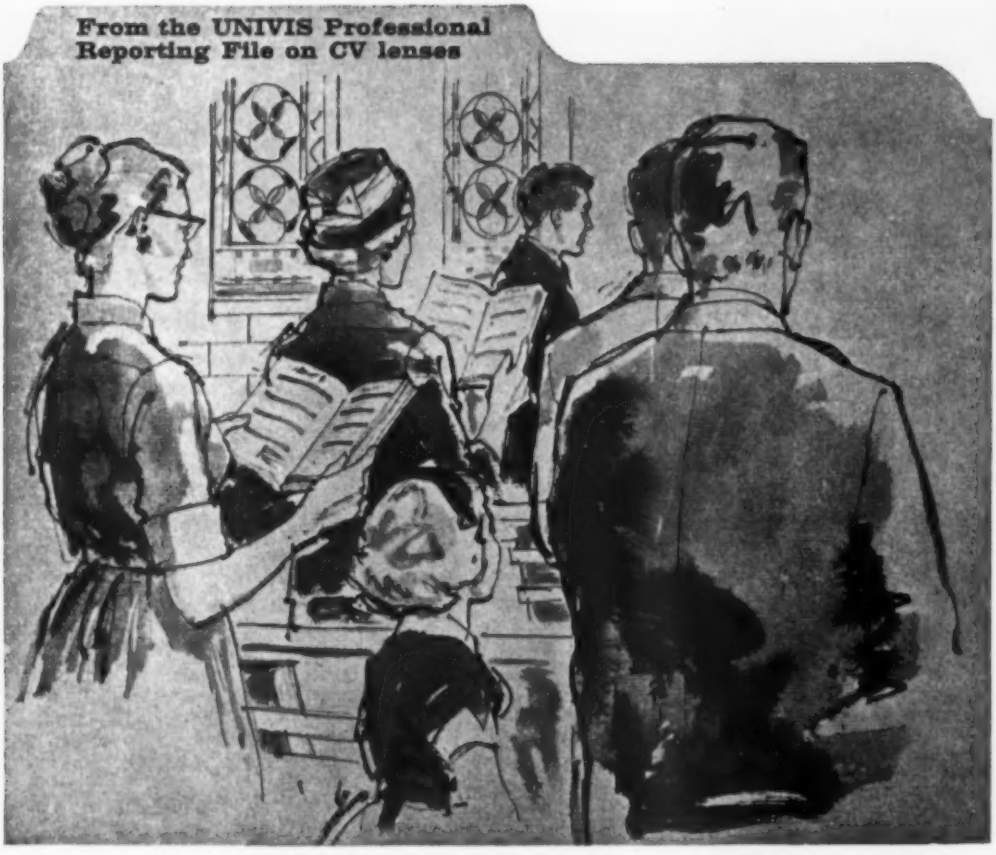

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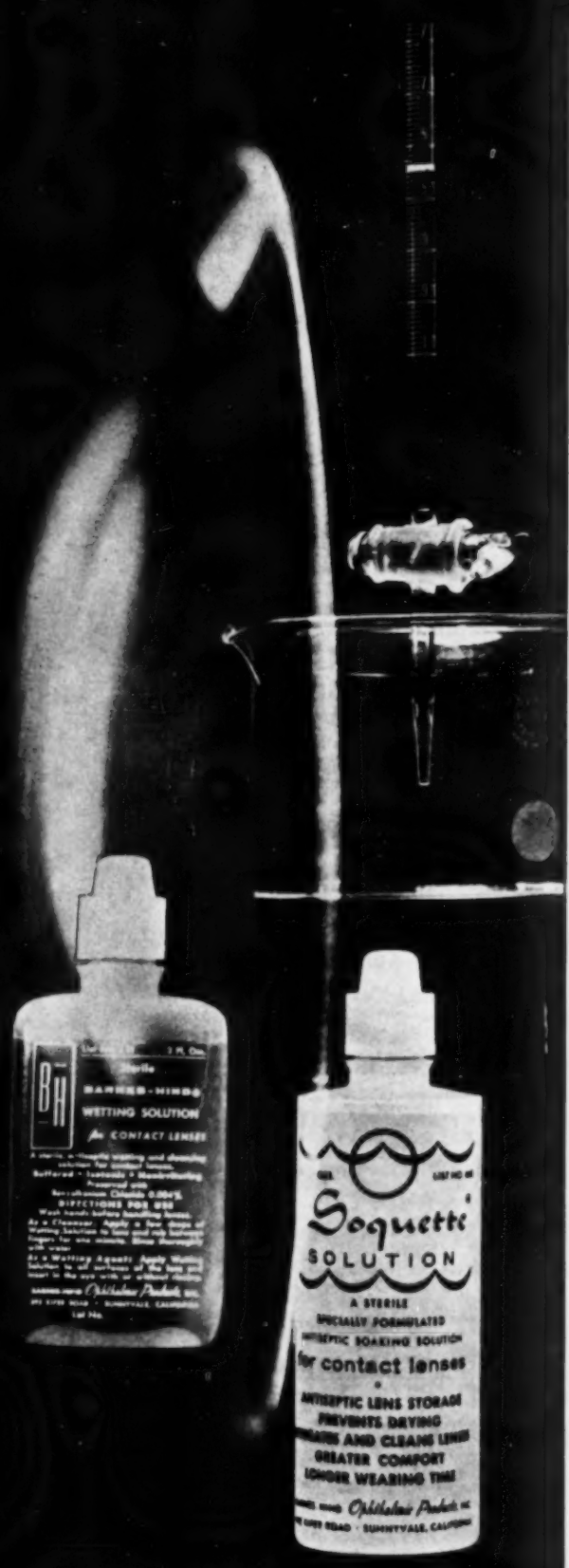

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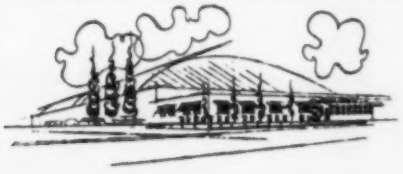

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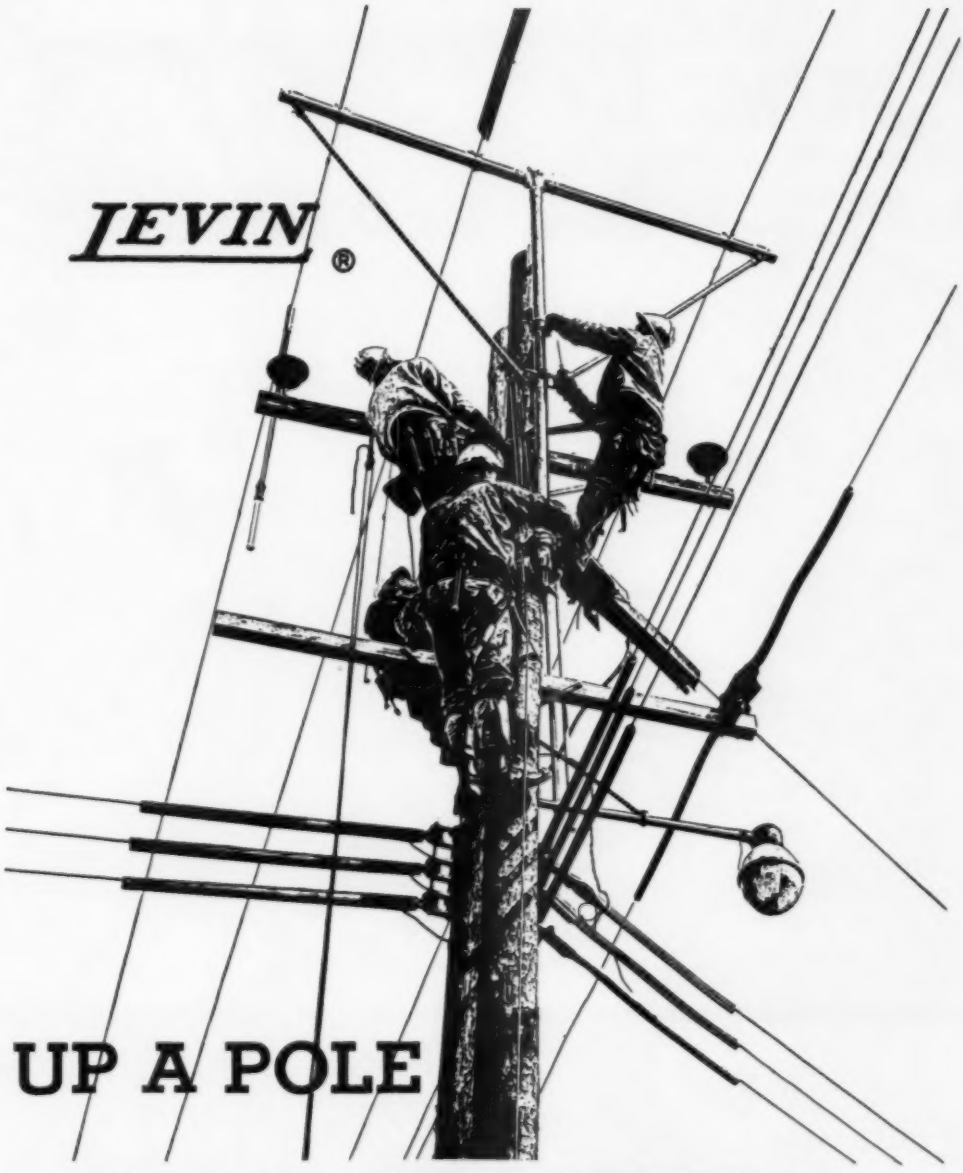

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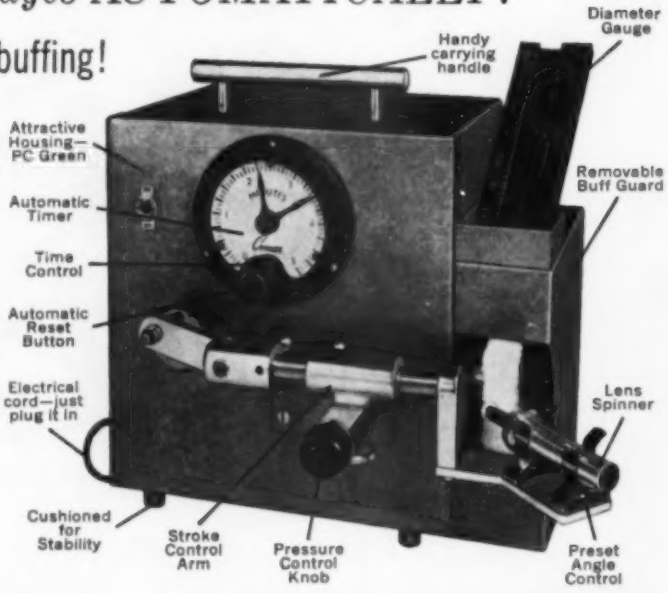

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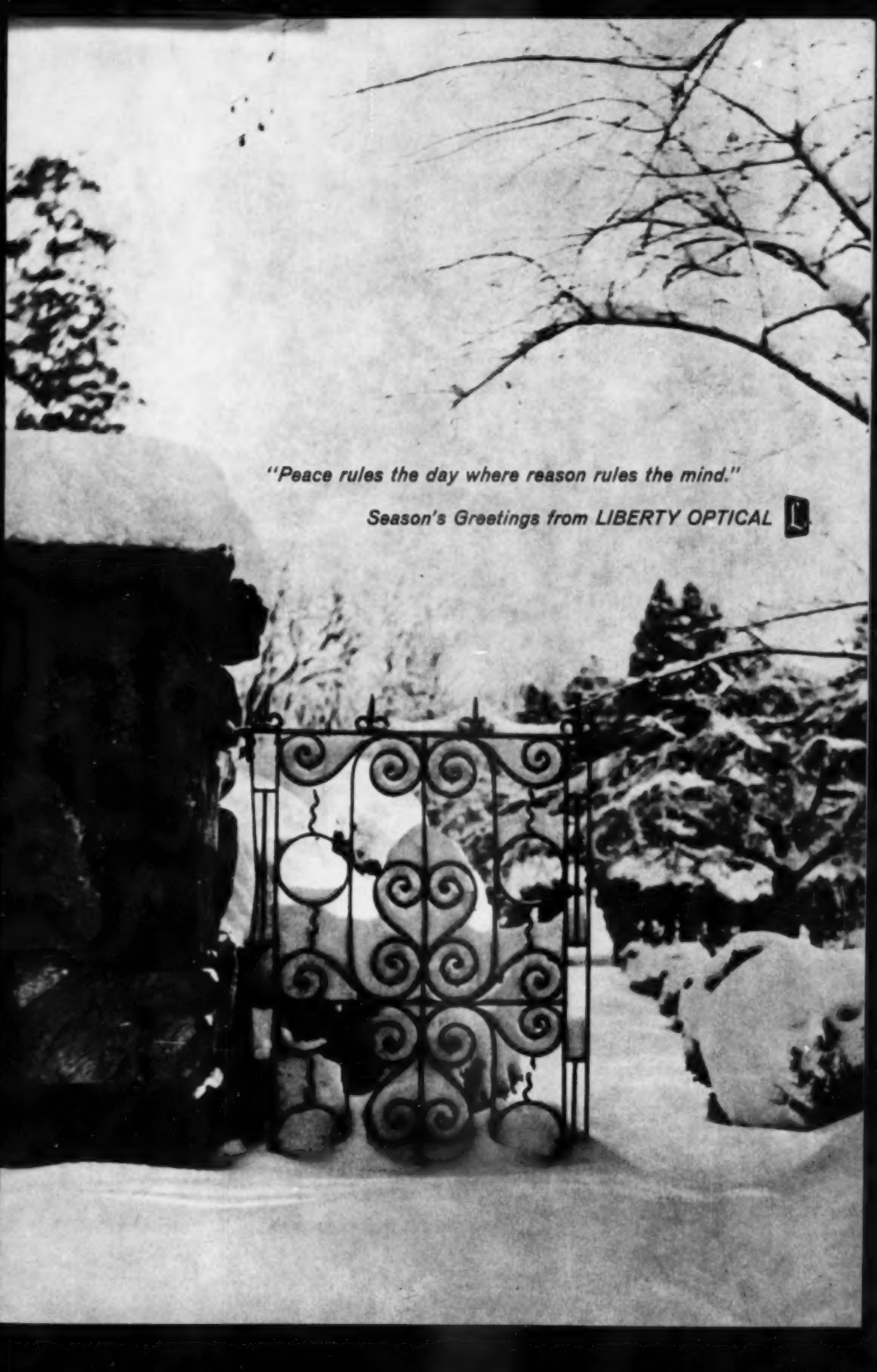
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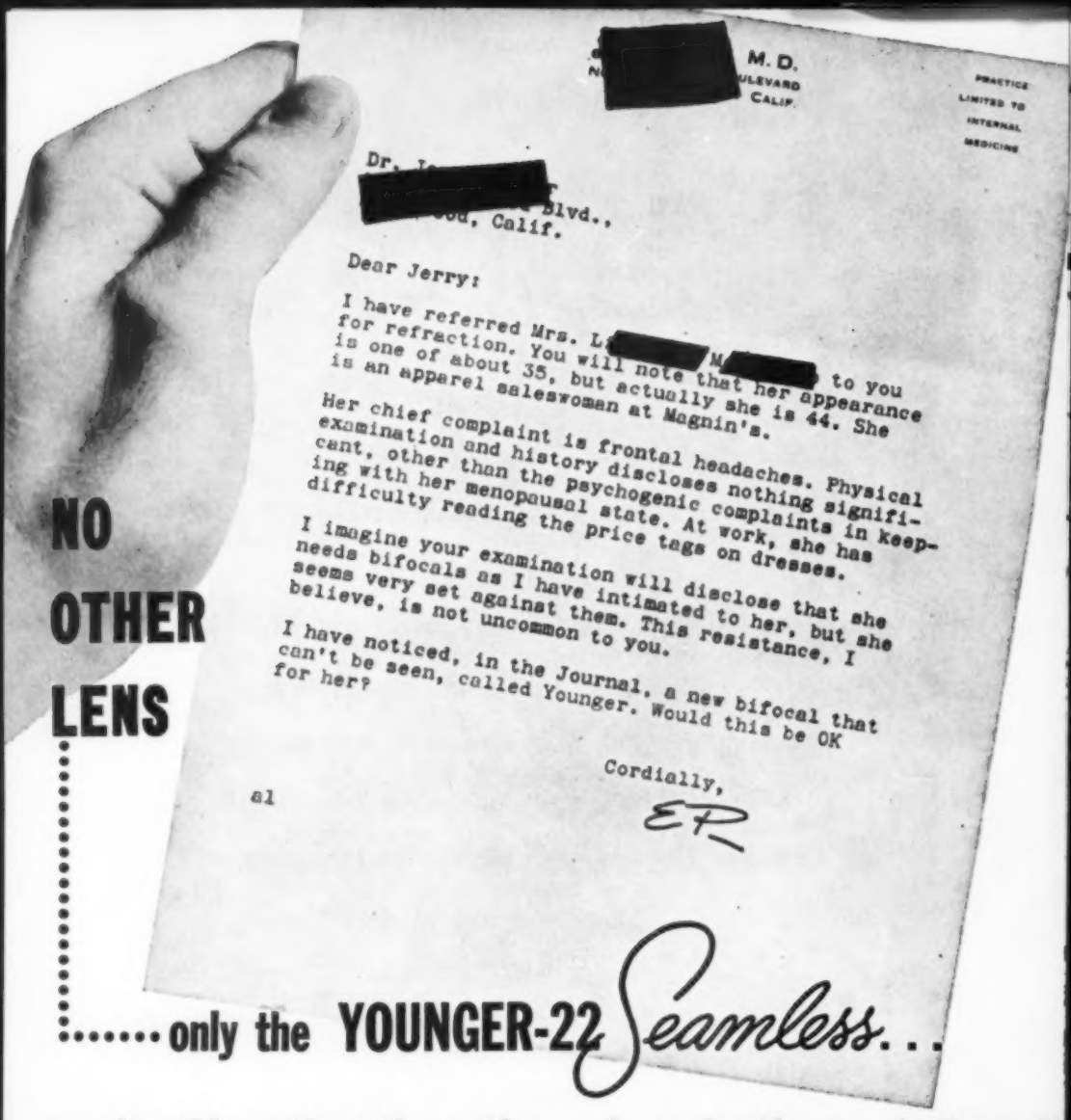
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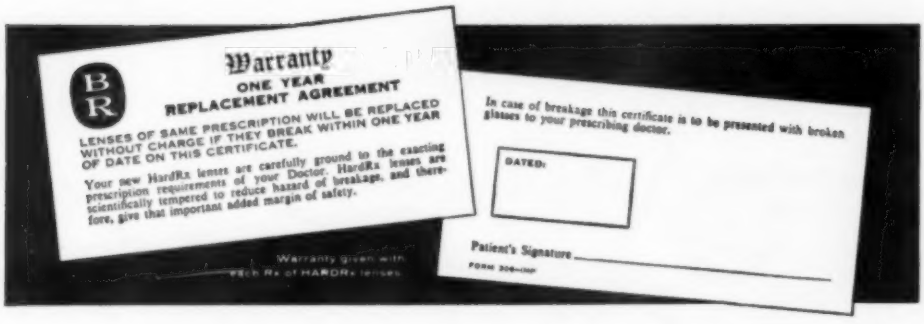
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Vol. 37 December, 1960 No. 12

THE TAJIRI METHOD FOR CUSTOM MOLDING SPECTACLE FRAME BRIDGE AND TEMPLES*‡

Monroe J. Hirsch†
Ojai, California

The idea of molding the bridge or temples of a spectacle frame so that they closely approximate the contours of the patient's face is not a new one. At least 20 years ago a method was in use for taking an exact mold of the back of the ear so that riding bow temples could be shaped precisely. However, no practical method has been available for custom molding plastic or aluminum frames.

Recently Archer** described a technique for applying plastic in its liquid form to the bridge or temples of a pair of spectacles and allowing it to harden and assume its final shape while on the patient's face. Archer's technique has the following characteristics:

(a) Dental rubber dam applied with adhesive tape is used to form a pocket over the bridge or temple.

(b) The moldable plastic is formed by combining a powder and a liquid which are supplied in a syringe and are separated from each other by a rubber diaphragm.

(c) After the frame has been prepared and is in approximate adjustment, a needle is passed through the nose of the syringe, perforating the diaphragm. The plunger then forces liquid and powder to combine forming a liquid plastic which is forced from the syringe.

(d) This substance is inserted into the pocket of rubber dam.

(e) The frame is placed on the patient's face and is held firmly in place until the plastic has hardened.

(f) The rubber dam is removed and the hardened plastic is trimmed.

When Archer's method is used for custom fitting a bridge or temple, the result is an overlay of hard plastic which has the exact contours of the patient's nose or skull behind the ears. The method is generally satisfactory but has several shortcomings which may be summarized as follows:

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*Submitted on August 27, 1960 for publication in the December, 1960 issue of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.

‡Developed by Akira Tajiri, O.D., Reedley, California.

†Optometrist. Ph.D., Fellow, American Academy of Optometry.

**Archer, John E. A demonstration and lecture before the Annual Congress of the California Optometric Association, February, 1958.

Fig. 1—Materials needed to custom fit a spectacle frame: Back row: Primer, catalyst, and base compound. Front row: Cotton tipped swab for applying primer, measuring spoon, glass mixing surface (a ceramic tile may be substituted), nail file for spatulating (a dental spatula or thin knife may also be used), and single edged razor blade for trimming (a scalpel may also be used).

(a) The plastic substance must be marketed in a syringe which can be used only once, thus adding considerably to the cost. The syringe is necessary to introduce the material into the rubber dam pocket.

(b) The plastic overlay sometimes becomes disconnected from the frame and must be re-cemented.

(c) The preparation of the frame by taping down rubber dam to create pockets is time-consuming.

(d) The plastic overlay which is ultimately formed is relatively rigid. For many patients, particularly the older patients, a softer substance would be more desirable.

More recently, Tajiri has experimented with other forms of plastic in an attempt to find a plastic which could come in direct contact with the skin (doing away with the need for rubber dam pockets), which would adhere to the spectacle frame and which would have a less rigid structure. He has developed such a substance and has formulated a much simpler procedure for custom molding parts of a spectacle frame. The necessary supplies are now being marketed.*

THE TAJIRI METHOD:

The necessary materials are illustrated in Figure 1. The three expended substances are (a) a primer which bonds the newly formed plastic to the frame, (b) the base compound (a variety of silicone elastomer which vulcanizes at room temperature) and (c) a catalyst (stannous octoate). These three products may be obtained from the

*Manufactured by the Tajiri Visual Products Company, P.O. Box 72, Reedley, Calif.

Fig. 2—Preparing the plastic: the base compound and catalyst are spatulated on the glass or tile surface.

manufacturer. The remaining supplies consist of a measuring spoon, a swab with cotton wrapped ends for applying the primer to the frame, a flat surface such as a piece of glass or ceramic tile on which the base substance and catalyst may be combined, and a spatula, knife or nail file for spatulating. In addition, a cleaning solution such as xylene or carbon-tetrachloride and cotton for its application are needed.

The following simple steps are performed in order to custom mold a bridge or temple of a metal or plastic (zylonite or lucite) frame:

(1) The frame is adjusted in the customary fashion to give the best possible fit.

Fig. 3—Applying the spatulated compound to the spectacle frame.

Fig. 4—Frame and compound on the patient's face. Note the excess compound which will later be trimmed away.

(2) The area to which the plastic will adhere is cleaned with solvent.

(3) The primer is applied to the appropriate area of the bridge or temple. At least five minutes must elapse during which time the frame should not be handled.

(4) A half teaspoon of base substance and four drops of catalyst are spatulated on the glass or tile mixing surface. (Figure 2.)

(5) The substance is applied to the prepared surface or surfaces of the frame. (Figure 3.) More than an adequate amount is applied.

(6) The frame is applied to the patient's face and is held in the position that is desired. The material will set in a few minutes, but it is suggested that it remain on the patient's face for about ten minutes; it need only be held in position for a minute or two, and may then remain without holding. (Figure 4.)

(7) The leftover material may be checked to determine when it has set. The frame is removed with the molding compound adherent to it.

(8) Excess material is trimmed off with a sharp razor blade or scalpel.

The material should be trimmed so as to look as neat as possible and still give the desired bearing surface (Figure 5). The patient is cautioned not to try to pry the material loose for the first 24 hours. He may wear the frame immediately.

The process for molding bridges and temples is the same except that in the case of temples, the substance may adhere to the hair. For

Fig. 5—Trimmed pads on a spectacle frame.

this reason a thin piece of wax paper is wrapped around temple and molding compound.

The adherent substance has the resistance of hard rubber. It yields to pressure but retains the conformity of the facial structures.

EVALUATION AND APPLICATIONS:

The method is not recommended for all patients since all do not require as precise a fitting as the method affords. The material cost is slight, but fitting by this method does take some time. With proper management, this can be reduced to a minimum. If the preparation and early steps are done by the office assistant and the optometrist comes in at the time the primer has set and the compound has been spatulated and is ready for application, about 15 minutes of the doctor's time will be required.

Not all patients will want to wait from a half to three-quarters of an hour in order to have a spectacle frame fitted. On the other hand, for many special circumstances, the method has great value. Certainly, the patient who is having difficulty with the physical fit of spectacles will benefit and will want this added service. Older patients whose lack of subcutaneous fat makes fitting difficult will benefit from having a bridge molded to fit precisely. Patients whose spectacles slip forward are also helped since the rubbery consistency of the compound tends to prevent slipping.

The method is of particular value for patients who have facial irregularities, particularly for those who have elevated skin blemishes in the region where the spectacles will rest. The frame can be molded so

that no part rests on the blemish. The author has used the method with success on patients who have had warts or moles on which the eyewire of a regularly adjusted spectacles rested. By building up the frame on either side of the elevation, it is possible to bridge the blemish.

Patients who must wear heavy plus lenses (cataract lenses) also will benefit. The author has used the method in regular optometric practice for about three months and finds that it is of value for about one out of every ten to 20 patients. Possibly as one gains facility and integrates the method into his regular office routine it would be used more frequently. Regardless of how frequently it is used, however, the method is of inestimable value for those patients whose spectacles can be satisfactorily adjusted in no other way.

The vast majority of optometrists consider the fitting and adjusting of spectacles as one part of the overall practice of optometry. While refinements in examination procedures and corrective procedures are constantly being made, improvements in techniques for proper fitting of spectacles are rare. The molding technique is one such advance and will probably soon become a part of the armamentarium of many optometrists. Through it, a better service can be offered to a group of patients who hitherto were torn between choosing the discomfort of wearing spectacles and the consequences of not wearing them.

NEW BOOK RECEIVED

YOUR FUTURE IN OPTOMETRY. James R. Gregg, O.D. Published by the Richard Rosen Press, Inc., New York City. 160 pages. Cloth. $2.95. 1960. One of an important *Careers in Depth* series. Very well done.

PHOTOGRAPHIC APPARATUS FOR STUDYING CONVERGENCE*

Charles R. Stewart†
College of Optometry, University of Houston
Houston, Texas

Photographic and other objective techniques for studying eye movements have been widely used for studying *monocular* and *conjugate* movements of the eyes. In this paper a photographic method of studying convergence movements is described.

For description, the apparatus may conveniently be divided into three components: (1) a photographic system to record lateral movements of the eyes, (2) a projection system to provide convergence stimuli, and (3) a film analyzer to determine convergence values from the photographic records.

The general arrangement of the photographic and projection systems is illustrated schematically in Figure 1. Subjects are seated 150 cm. from a cylindrical screen, S, whose axis of rotation, X, passes vertically through the center of an imaginary line connecting the centers of rotation of the two eyes. The screen measures 8 feet horizontally and

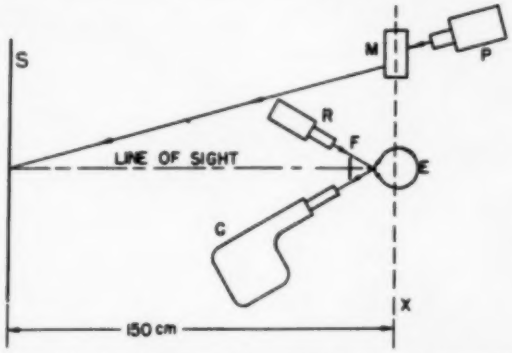

Fig. 1. Side view showing general arrangement of the photographic and projection systems.

*This paper is excerpted and condensed from a dissertation, "A Photographic Investigation of Lateral Fusional Movements of the Eyes," submitted in 1951 to the Graduate School of The Ohio State University. At that time the author was a graduate student in the school of Optometry. Submitted September 1, 1960.

†Optometrist. Ph.D. Dean and Professor of Optometry. Fellow, American Academy of Optometry.

4 feet vertically. A projector, P, is located above and behind the subjects head, and the projector beam passes through a doubling device, M, located directly above the subject's head on the axis of the cylindrical screen. The subject views the screen through filters placed one in front of each eye at F. A light source, R, is placed above and in front of each eye so that its beam passes over the filter to the eye, from which it is reflected under the lower edge of the filter and into the camera, C, which records the eye movements. The device used to analyze the photographic records is shown in Figure 6 and is described last.

PHOTOGRAPHIC SYSTEM

The essential features of the photographic system are shown in Figure 2. The camera is a modified American Optical Company Ophthalmograph and the light sources, R, are streak retinoscopes with the mirror assemblies removed. The line filaments of the retinoscopes are adjusted to form vertical images on the corneas. Further elongation of the filament images is obtained by incorporating cylindrical lenses into the camera lens system. As illustrated by the inset at the lower right of Figure 2, a narrow horizontal slit placed immediately in front of the film allows only a small strip of each image to reach the film. An electromagnetically operated shutter is located in front of the slit.

For focusing the images in the film plane, the Ophthalmograph contains a mirror which can be dropped into the light path to reflect the two beams to a ground glass screen located in the top of the camera at an

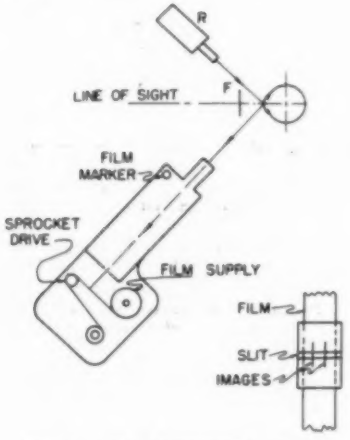

Fig. 2. The photographic system.

optical distance from the subject's eyes equal to that of the film. A line corresponding to the slit is etched on the ground glass. Accurate positioning and focussing of the camera images may be obtained by viewing the images on the ground glass with a 6.5 X hand magnifier.

Motor vibration in the camera is eliminated by turning the sprocket film drive with a modified phonograph turntable assembly mounted independently and a short distance away from the camera. The motor is geared to move the film past the slit at the desired rate, in this case approximately 0.60 inch per second.

The film marker, used to mark the film for identification of subject, time, etc., consists of a small lamp mounted inside the camera housing. The "on" current to the lamp filament is regulated to allow just enough illumination upon the slit to fog the film slightly as shown by the dark regions at the right and left in Figure 5. The "off" current is sufficient to produce a just visible glow of the filament but insufficient to register when the film is moving past the slit.

To obtain convergence records it is required to measure between corresponding points on the photographic records of the right and left eyes. The vertical images focussed on the horizontal slit satisfy this requirement and one can measure between corresponding points simply by measuring across the film between the two monocular records in a direction perpendicular to the edge of the film; that is, parallel to the slit. This camera arrangement also has the advantage of registering on the film only horizontal components of the eye movements.

PROJECTION SYSTEM

A plan view of the projection system is shown in Figure 3. After passing through the objective lens of the projector, the beam from a point, O, in the object plane is divided at the red and green Corning

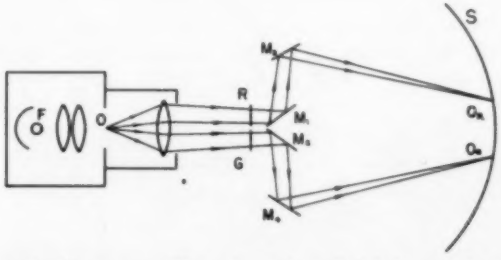

Fig. 3. The projection system. The axis of the cylindrical screen is vertical and the mirrors lie in vertical planes, but the axis of the projector is inclined downward as shown in Figure 1.

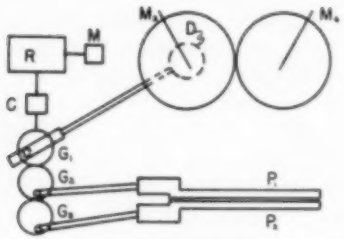

Fig. 4. Mechanism for producing size changes.
A. Plan view.

filters, R and G. (H. R. Signal Red Color Spec. No. 2-60 and Sextant Green Color Spec. No. 4-64 were selected because for practical purposes there is no overlap in their visible transmissions.) Immediately beyond the filters and approximately on the axis of rotation of the cylindrical screen, two plane mirrors M_1 and M_2 are mounted vertically, perpendicular to each other and each at 45 degrees to the incident light path. One beam is reflected to the left and the other to the right to mirrors, M_3 and M_4, and then to the screen, S. O_R and O_G on the screen represent the doubled images, one red and the other green, of the single point, O, in the object plane of the projector.

The mirrors, M_3 and M_4, each are mounted to rotate around vertical axes and are geared together so that when set in motion O_R and O_G are displaced horizontally, in equal amounts but opposite directions across the screen. Because of the cylindrical shape of the screen, the images can be moved back and forth across the full width of the screen without changing the focus or size of the images.

If filters which are identical to those mounted in front of the

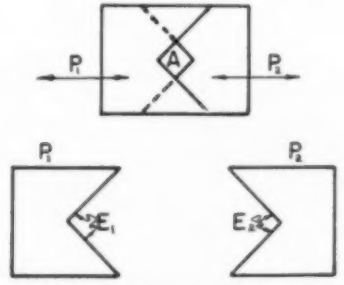

Fig. 4. Mechanism for producing size changes.
B. Front view of knife edge arrangement.

projector are also mounted in front of the subject's eyes, each eye can see only one of the images on the screen.

One of the targets used with this projection system consists of a diamond shaped quadrilateral whose size can be varied by means of the device shown in Figure 4. Two knife edges, E_1 and E_2, (Figure 4B) are attached to plates, P_1 and P_2. These plates are linked to the eccentric pins on gears, G_2 and G_3, (Figure 4A) which rotate in opposite directions and drive the plates back and forth in the object plane of the projector, with one moving back when the other moves forth. As the plates slide back and forth the diamond shaped aperture, A, (Figure 4B) alternately expands and contracts. The amount of this expansion can be controlled by adjusting the eccentricity of the pins on G_2 and G_3. When the gears are in motion, the velocity of the size changes varies as a sine function, with zero velocity at the maximal and minimal sizes.

A slot in the lever which extends from the gear system of the rotating mirrors, M_3 and M_4, rides on an adjustable eccentric pin on G_1. As G_1 rotates the lever is moved back and forth with the result that the red and green images of A are moved laterally back and forth on the screen, moving in opposite directions as they pass each other at the center of the screen. (M_3 and M_4 of Figure 4 are the same mirrors as M_3 and M_4 of Figure 3.) The velocity of the lateral movement of the targets also varies as a sine function, and, when the three gears, G_1, G_2 and G_3, are properly adjusted and connected to the output shaft of an electromagnetic clutch, C, the velocity and lateral separation of the targets reaches zero and maximal values in synchrony with the velocity and limits of the size changes.

The input shaft of C is driven by an electric motor, M. Speed of rotation of the three gears can be set at any desired value by means of a mechanical speed control device, R.

When a subject views the red and green images of A through the red and green filters, the device just described produces size changes and convergence stimuli exactly duplicating those which would result from the fore and aft movement of an object in space. A sample photo-

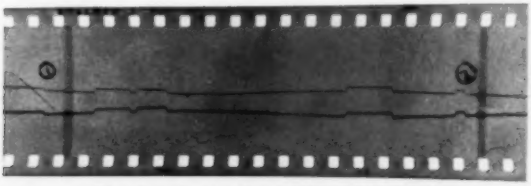

Fig. 5. A sample photographic record.

graphic record of the lateral components of eye movements during a complete cycle is shown in Figure 5.

By manipulating the various adjustments mentioned, one can obtain a number of variations of size changes and convergence stimuli. The convergence cycle can be reversed with respect to the size cycle, either cycle can be held fixed at a given value, or the size changing device can be removed and other convergence targets projected on the screen without size changes. The device also may be modified to provide "jump" stimuli of various magnitudes in either a base-in or a base-out direction.

FILM ANALYZER

The film analyzer was designed and constructed to provide the means for rapid and accurate transcribing of changes in convergence from the photographic records depicting the lateral movements of the eyes. It also has been used to transcribe and analyze photographic records of accommodation, pupil size, and monocular eye movements. The principles involved may conveniently be applied to the general situation in which it is desired to obtain a continuous record of changes in separation between two continuous lines on a film. In order to illustrate the use of the apparatus, the specific problem for which it was designed is described.

Figure 5 is a sample photographic record of the type of eye move-

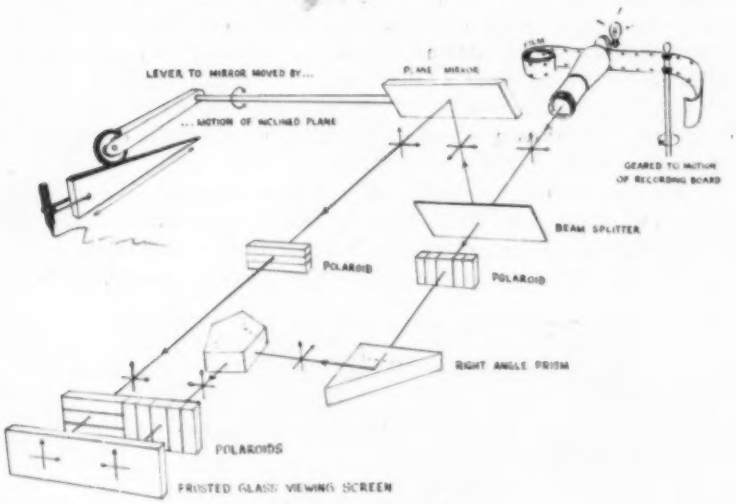

Fig. 6. The film analyzer.

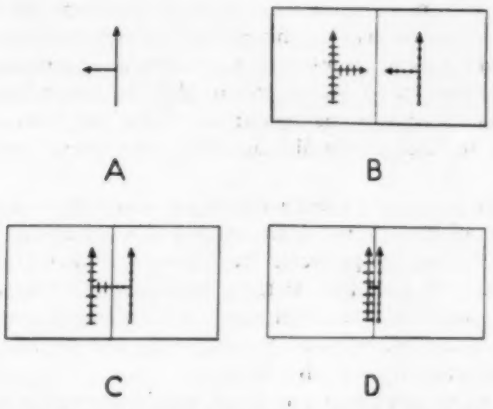

Fig. 7. B, C, and D illustrate the movement of the two polarized images on the viewing screen when an object such as A is moved through the projector plane of the film analyzer.

ments which the device is designed to analyze. The upper line on the film depicts the movements of the left eye, the lower line the movements of the right eye. So long as the eyes are stationary, parallel straight lines are produced on the film, but lateral movements of the

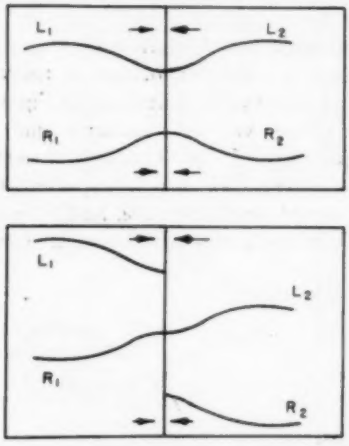

Fig. 8. Schematic illustration of the appearance of the doubled image of a photographic record of convergence as seen on the viewing screen of the film analyzer. Images aligned as in A will flow into each other at the dividing line. When aligned as in B, R_1 and L_2 may be continuously aligned as they flow into the dividing line by rotating the plane mirror shown in Figure 6.

eyes produce corresponding deviations of the lines on the film. With the apparatus used in making this record, vertical movements are not registered. The specific problem is to obtain a continuous record of changes in the amount of convergence in play, by transcribing a continuous record of changes in the separation of the two lines on the film. The essential features of the film analyzer are shown schematically in Figure 6.

The film is pulled through the object plane of a projector by a sprocket drive which is geared to the motion of a motor-driven recording board. After leaving the projector the beam is split, and the two resulting beams are cross polarized so that, after passing through the sheets of polaroid material attached to the rear of the viewing screen, the right half of the screen is illuminated by one beam and the left half of the screen is illuminated by the other beam.

It should be noted that one beam travels through a prism system which reverses right for left in the image formed on the viewing screen. Thus, if an object such as that illustrated in Figure 7A is placed in the object plane of the projector, two polarized images as represented in Figure 7B will be formed on the screen. If the object is displaced laterally in the projector, the two images will move in opposite directions, and they can be made to flow into each other and disappear at the junction of the crossed polaroids as illustrated consecutively by Figures 7-B, C, and D.

When a photographic record, such as the one illustrated in Figure 5, is placed in the projector, the two images on the viewing screen may be made to appear as schematically illustrated in Figure 8A by adjusting the plane mirror to obtain vertical alignment and moving the screen laterally until the junction of the crossed polaroids falls at identical positions in the two images. L_1 and L_2 represent the doubled image of the photographic record for the left eye, and R_1 and R_2 represent that of the right eye. When the film record is pulled through the projector,

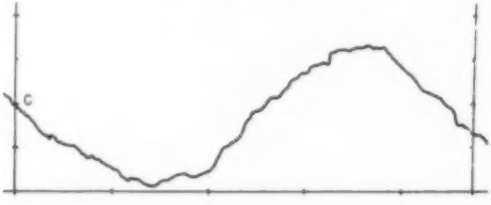

Fig. 9. The convergence record transcribed with the film analyzer from the photographic record shown in Figure 5.

L_1 and L_2 will flow into each other at the dividing line, as also will R_1 and R_2. If, however, the plane mirror is adjusted so that the images are vertically separated as in Figure 8B, then R_1 and L_2 will flow into each other, but only so long as the separation of L and R remains constant. When the film is pulled through the projector and R_1 and L_2 begin to separate, they can be realigned by rotating the plane mirror (Figure 6), which is accomplished by fore and aft movement of the inclined plane. The same lever system which controls the movement of the inclined plane also displaces the recording pen in a direction perpendicular to the motion of the recording board.

To obtain a convergence record, the beginning of the film record is adjusted as in Figure 8B. The motor which drives the recording board and film drive is started, and the operator manipulates the control lever to keep R_1 and L_2 flowing into each other at the dividing line on the screen. So long as the operator does not move the control lever, the recording pen draws a straight line on the recording board beneath it. But every movement of the control lever, to align the images by rotating the mirror, produces a corresponding movement of the recording pen perdendicular to the direction of movement of the recording board. It can be shown that the displacement of the pen necessary to realign L_1 and L_2 after they separate is directly proportional to their separation and, therefore, also directly proportional to the corresponding change in distance between the two lines, L and R, on the film. Thus, the line traced on the recording board gives a continuous record of convergence changes.

Figure 9 is a convergence record thus transcribed from the film in

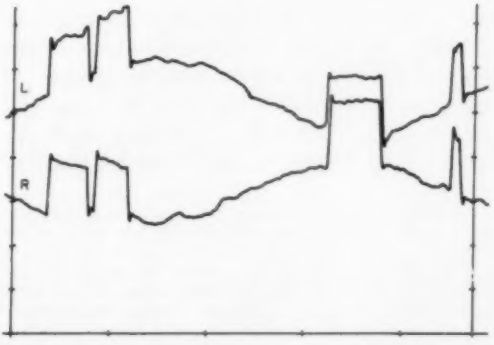

Fig. 10. Magnified traces of the individual lines from the film shown in Figure 5.

Figure 5. Figure 10 shows magnified traces of the individual lines from the film in Figure 5, separately traced with respect to a fixed point on the dividing line of the viewing screen.

The desired magnification of the eye movement records can be obtained by adjusting the slope of the inclined plane, and the magnification along the time scale is determined by the gear ratio between the recording table and the film drive.

Ink containing glycerine is used to avoid clogging of the pen with dried ink.

ACKNOWLEDGMENTS

The author is grateful to Dr. Merrill J. Allen and Dr. Glenn A. Fry for their helpful suggestions and ideas, many of which are incorporated into the apparatus described in this paper.

The author also expresses his appreciation for the financial support which he received from the American Optometric Foundation.

ANNOUNCEMENT

UNIVIS MOVES TO NEW FACILITY EXPANDS PRODUCT LINES, CHANGES CORPORATE NAME

A broad expansion program, involving product diversification, new modern facilities, a plant move from Ohio to Florida, and a corporate name-change, were announced November 15.

Robert O. Barber, president, stated that The Univis Lens Company was changing its name to Univis, Incorporated to reflect the company's expansion program adding: "A wide range of additions to our product line is underway, including hearing aids, eyeglass frames and related products: lenses to control glare, multifocal lenses, plastic lenses for ophthalmic and industrial uses and plastic components for the Armed Forces. Our program of diversification to produce growth has motivated our decision to move from our present location which cannot provide the needed added facilities, to Vision Park, a newly created, 20-acre site at Ft. Lauderdale, Florida, adjacent to the Broward County Airport." Mr. Barber outlined these highlights of the Univis program:

Ophthalmic Eyeglass Lenses, a complete product line of bifocals and Continuous Vision (tri-focal) lenses. *Quality Glare Control Lenses* being worn year 'round as well as for summer sunlight by those who recognize the adverse effects of glare. *Safe-T-Vis Plastic Unbreakable Lenses* being used by an increasing number of patients to insure safety. *Contact Lenses*, the fastest growing phase of the industry, and one in which Univis is setting new quality standards. *Plastic Components for the Armed Forces* resulting from space age developments. *Univis-Bishop Eyeglass Frames* for men, women and children. *Vita-Tone Hearing Aids*, representing advanced developments with emphasis on eyeglass frame hearing aids.

ON THE RELATIONSHIP BETWEEN ACCOMMODATION AND ACCOMMODATIVE CONVERGENCE*

Part III. EFFECTS OF ORTHOPTICS

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Those experienced in orthoptic training know of the ease with which the amplitude of positive relative convergence can be increased. However, changes in the relationship between accommodation and accommodative convergence (the AC/A ratio) are not so readily demonstrable. Many authors have therefore reported that the AC/A ratio is uninfluenced by orthoptics.[1-5] Recently, Manas[6] demonstrated an average increase of 0.5Δ/D. in the AC/A ratio calculated from clinical measurements of the distant and near phorias in 200 patients who received twelve elementary orthoptic treatments over a six-week interval. Since he did not have a control group, did not measure accommodative response, and made no attempt to minimize the influence of proximal convergence, it is possible to interpret his observed increase in AC/A ratio as resulting from 1) a practice effect associated with testing, 2) a small (e.g., 0.12 D.) increase in accommodative response at near following orthoptics, or 3) an increase in proximal convergence. The present investigation was designed to furnish evidence bearing on these interpretations and thereby establish whether an increase in AC/A ratio with orthoptics is genuine.

The plan was to use subjects having more than average exophoria at near, poor fusional convergence, and ocular symptoms associated with reading. Some of these subjects (experimental group) were to receive orthoptics three times a week to improve positive relative convergence. The remaining subjects (control group) were not to receive orthoptics. All subjects were to report for weekly measurements of the AC/A ratio and positive relative convergence in order to follow possible changes that might occur. There was no attempt to "train" the control subjects: moreover, there was no "suggestion" that their visual situation might be improved by the regime.

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Optometrist, Ph.D. Member of faculty, Fellow, American Academy of Optometry.

EXPERIMENTAL PROCEDURE

PHASE I

This phase of the experiment included an experimental group of 94 subjects who received three 30-minute orthoptic treatments a week for about eight weeks. Twenty-four control subjects were selected from available optometry students. In spite of efforts to equate the two groups, the experimental subjects had about 1 Δ more exophoria at distance and about 4 Δ more at near: consequently their average AC/A ratio was about 1 Δ/D. less than the control subjects'. Eleven of the experimental group who returned one year after orthoptics was completed comprised a follow-up group.

Any existing ametropia was corrected and the refractor was set for the subject's interpupillary distance for the two fixation distances used. The lateral phoria was first measured with a red Maddox rod and Risley prism centered before one eye while fixation was maintained with the other eye on a point source of light at 6 M. The nonfixating eye was briefly uncovered several times, each time the subject reported the position of the line with respect to the light. The midpoint of the range of uncertainty was recorded as the lateral phoria. A similar procedure was employed in measuring the phoria at 40 cm. except that the von Grafe prism-dissociation method was used: the target was a black 1 cm. square containing many fine vertical lines on a white background. Measurements were made by third-year optometry students who were unaware of the nature of the experiment.

PHASE II

Twelve college students served as subjects for this phase of the experiment. There were eight experimental subjects who received orthoptics thrice weekly for about eight weeks; five of them returned for examination one year later. Four optometry students served as control subjects. Two of them (M.K. and J.O.) had ocular symptoms associated with reading.

Each trial lasted about 40 minutes and consisted first of 20 measurements obtained with a refractor (five measurements, four accommodative levels) and then 20 measurements with a haploscope. The stimuli to accommodation were presented in the following order: 0.0, 2.5, 1.5, and 3.5 D. All measurements were made with any ametropia corrected and with the right eye fixating.

With the refractor the lateral phoria for the zero-diopter accommodative stimulus was determined with a Risley prism and a red Maddox rod (axis horizontal) centered before the left eye; a small point source of light was viewed by the right eye at a distance of 6 M. A 40 cm. fixation distance was used for the other accommodative

stimuli: a Risley prism was centered before the left eye and a 6Δ base-down prism before the right: the target, consisting of a black 1 cm. square containing many fine vertical lines on a white background, was centered in the median plane. Lenses of +1.00 D. and —1.00 D. were added binocularly to produce the accommodative stimuli of 1.5 and 3.5 D., respectively. The procedure was to place an occluder before the left eye and then to uncover the eye briefly so that the subject obtained a brief exposure of the vertical streak (at 6 M.) or of the lower diplopic image of the square (at 40 cm.). The subject judged whether the briefly seen image was to the left or right of the target continuously fixated by the right eye. The power of the Risley prism was changed in steps of 0.5 Δ at random and the response at each setting was noted. Between six and ten settings were usually required to establish the limits of the interval of uncertainty. The midpoint of this interval was recorded as the lateral phoria. Five measurements were obtained in this fashion at each accommodative level.

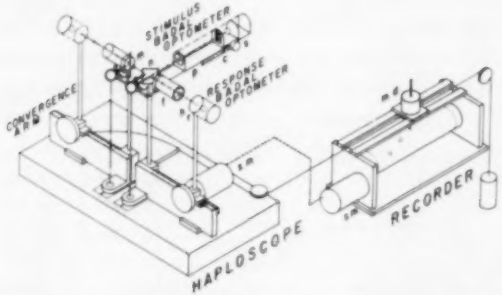


Fig. 1. Haploscope and recorder. Source (s) transilluminates chart (c) which is imaged by lens (p). Right eye sees this image through semi-silvered mirror (n) as well as a reflected image of pinhole (h). Subject adjusts this pinhole (h) and trans-illuminating source (r) with respect to lens (f) and generates voltage in selsyn motor (s.m.) which is transmitted to second motor (s.m.) causing rotation of recording drum. The image of another pinhole is reflected into left eye by fully silvered mirror (m): convergence is measured by rotation of left haploscope arm which, by means of pulleys and weights, moves a marking device (m.d.) along abscissa of graph.

With the haploscope (Fig. 1) the right eye was directed straight ahead to view a target that consisted of a photographically reduced test chart in a Badal optometer. Movement of the chart toward the eye produced an increase in accommodative stimulus without a change in the angular magnification of the chart. The accommodative response with respect to the 15 mm. spectacle plane of the right eye was determined by subjective stigmatoscopy; the subject fixated a letter of five

minutes overall subtense and adjusted the position of a pinhole on the right haploscope arm until a red spot, imaged in a semi-silvered mirror, appeared to have its smallest diameter. At the same time the subject rotated the left haploscope arm around the center of rotation of the eye until a small green spot, reflected into the eye by a fully silvered mirror, was seen below the letter but vertically aligned with it and the red spot above. The convergence of the left eye and the corresponding accommodative response of the right eye were plotted on x,y coordinates by an automatic recording device.

The amplitude of positive relative convergence was obtained with rotary prisms in a refractor. Letters, 5 mm. in size, were viewed at a distance of 40 cm. and the power of the prisms was slowly and symmetrically increased before the eyes until a sustained blurring of the letters occurred or, in the absence of blurring, until diplopia was reported.

RESULTS

PHASE I

The AC/A ratio was calculated from each set of data according to the formula $200\ a + b_n\ (P_n - P_o)$ where the interpupillary distance, 2a, and the near fixation distance, b_n, are in meters and the lateral phorias at near, P_n, and at distance, P_o, are in prism diopters (esophoria is considered positive). From the data summarized in Table I it can be seen

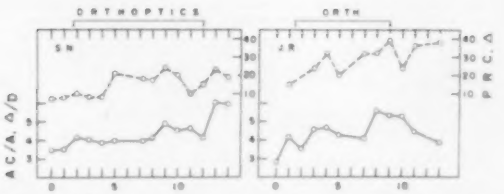
TABLE I

Change in lateral phorias and calculated AC/A ratio with orthoptics

		Exo 6 M Δ	Exo 40 cm Δ	AC/A ratio Δ/D
Control Group: examined weekly for five weeks, no orthoptics. N = 24	Initial	0.71	3.63	5.21
	Post	0.31	3.46	5.13
	Change	—0.40	—0.17	—0.08
Experimental Group: received orthoptics for low convergence for eight weeks. N = 83	Initial	2.01	7.70	4.23
	Post	1.65	6.41	4.64
	Change	—0.36**	—1.29**	+0.41**
Follow-up Group: received orthoptics for low convergence for eight weeks. N = 11	Initial	0.91	6.86	4.13
	Post	1.05	5.41	4.76
	Change	+0.14	—1.45	+0.63
Follow-up Group: subjects examined one year later N = 11	Post	1.05	5.41	4.76
	Yr. later	1.18	6.27	4.47
	Change	+0.13	+0.86	—0.29

**indicates significance by paired comparison t-test at 1% level.

that for the control group the mean exophoria at distance and near as well as the mean calculated AC/A ratio became somewhat smaller after five weeks of testing, but none of these changes was statistically significant. In contrast, the experimental group showed a significant reduction in the mean exophoria that was greater at near than at distance



Figs. 2 through 5. AC/A ratio and positive relative convergence plotted as a function of time. AC/A ratio based on accommodative response data obtained with haploscope. Positive relative convergence measured with Risley prisms at 40 cm. fixation distance.

with the result that the mean calculated AC/A ratio increased by 0.41 Δ/D. (significant by paired comparison t-test at 1 per cent level) after eight weeks of orthoptics. The follow-up group showed a mean increase of 0.63 Δ/D. in the AC/A ratio with orthoptics, but during the year following treatment it decreased by 0.29 Δ/D. from the post-orthoptic level (neither change is statistically significant). To be able to demonstrate significance with variances and mean changes of the observed magnitudes for the follow-up group would require a much larger sample.

PHASE II

The haploscope data from each trial were plotted in two ways.[7] In one plot the ordinate was the accommodative *stimulus*, in the other it was accommodative *response;* in both the abscissa represented accommodative convergence. The refractor data were plotted with accommodative stimulus versus accommodative convergence. Ordinary regression methods were used to fit a straight line to the stimulus data. When fitting the accommodative response data, an appropriate statistical method (described by Madanesky[8]) was used to allow for the fact that both of these variables are dependent and subject to error. In each instance the reciprocal of the slope of the fitted straight line was taken as the AC/A ratio.

The positive relative convergence and the haploscopically measured AC/A ratio for the experimental subjects are plotted as a function of

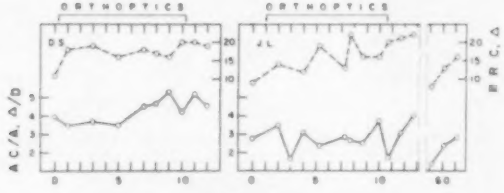


Fig. 3

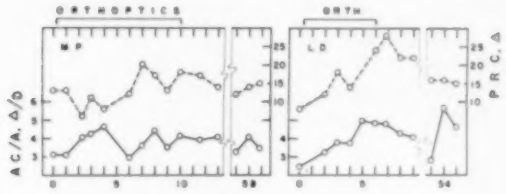


Fig. 4

time in Figs. 2 through 5. It is evident from the plots that during the orthoptic interval both the AC/A ratio and the positive relative convergence show a trend of increasing values. This trend is confirmed by the fact that all eight subjects have a positive rank correlation between AC/A ratio and trial number, in five instances this correlation is statistically significant (Table II). Interestingly, these significant rank correlations were for the haploscope response AC/A ratios; in no case was there a significant correlation between the refractor AC/A ratio and trial number. This may well be a consequence of the greater variability in the AC/A ratio as measured with the refractor.[9] In any event, it is clear that this experimental group demonstrates an increase in the AC/A ratio during the period of orthoptics since the occurrence of sixteen positive rank correlations out of a possible sixteen would take place by chance far less than once in one thousand times. When these positive rank correlations are contrasted with the negative ones obtained for the control subjects (Table II), it becomes necessary to interpret the increase in AC/A ratio for the experimental group as one related in some way to the orthoptics itself and not to weekly testing.

In order to assess the magnitude of the increase in the AC/A ratio during the period of orthoptics, the orthoptic interval was divided into two equal or nearly equal intervals (for an odd number of trials the first interval contained one more trial). The mean AC/A ratios for the two intervals are compared in Table III. The average difference in AC/A ratio between the first and second half of the orthoptic interval

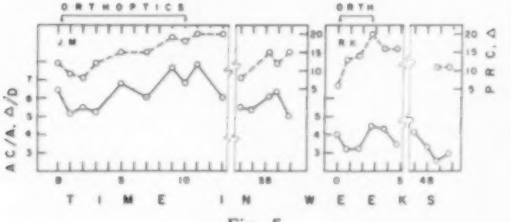


Fig. 5

TABLE II

Rank correlation between AC/A ratio and trial

		—During Orthoptics—		—Control Period—	
		Hapl.	Refr.	Hapl.	Refr.
Subj.	N	AC/A	AC/A	AC/A	AC/A
L.D.	6	+0.89*	+0.43		
R.K.	8	+0.40	+0.40		
J.L.	9	+0.02	+0.57		
J.M.	8	+0.67*	+0.07		
M.P.	10	+0.28	+0.36		
S.N.	11	+0.64*	+0.27		
D.S.	10	+0.69*	+0.50		
J.R.	11	+0.81*	+0.13		
M.A.	10			—0.06	—0.43
J.O.	10			—0.03	—0.88**
S.K.	9			—0.03	—0.14
M.K.	9			—0.33	+0.43

* indicates significance at 5% level. ** 1% level.

is an *increase* of 0.66 Δ/D. (haploscope response) or 0.32 Δ/D. (refractor stimulus). Both of these increases are significant by the t-test at the 1 per cent level.

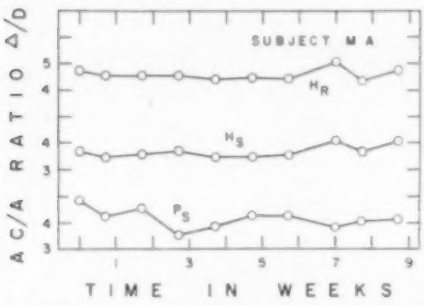
After the orthoptic treatments were discontinued, all the subjects

TABLE III

Change in AC/A ratio with orthoptics

		—Mean AC/A ratio, Δ/D—						
		Orth. half interv.		Immed. post orth.	One year later	—Change in AC/A ratio—		
		First	Second					
Subj.	Method	A	B	C	D	B - A	C - B	D - C
L.D.	Hapl.	3.59	4.91	4.38	4.42	+1.32	—0.53	+0.04
	Refr.	3.34	3.91	3.75	2.87	+0.57	—0.16	—0.88
R.K.	Hapl.	3.60	3.84	3.89	3.25	+0.24	+0.05	—0.64
	Refr.	2.83	3.26	3.75	3.15	+0.43	+0.49	—0.60
J.L.	Hapl.	2.64	2.93	2.96	2.20	+0.29	+0.03	—0.76
	Refr.	3.17	3.66	4.14	2.86	+0.49	+0.48	—1.28
J.M.	Hapl.	5.66	6.85	6.93	5.66	+1.19	+0.08	—1.27
	Refr.	3.81	4.11	5.12	5.70	+0.30	+1.01	+0.58
M.P.	Hapl.	3.79	3.91	3.99	3.60	+0.12	+0.08	—0.39
	Refr.	3.85	3.97	4.53	3.98	+0.12	+0.56	—0.55
S.N.	Hapl.	3.99	4.45	5.98	.....	+0.46	+1.53	.....
	Refr.	3.30	3.76	3.72	.....	+0.46	—0.04	.....
D.S.	Hapl.	3.79	4.72	4.85	.....	+0.93	+0.13	.....
	Refr.	3.70	3.87	4.03	.....	+0.17	+0.16	.....
J.R.	Hapl.	4.26	4.99	4.53	.....	+0.73	—0.46	.....
	Refr.	1.80	1.84	2.06	.....	+0.04	+0.22	.....
Mean	Hapl.	3.92	4.58	4.69	3.83	+0.66**	+0.11	—0.60
	Refr.	3.23	3.55	3.89	3.71	+0.32**	+0.34*	—0.55

* indicates significance by paired comparison t-test at 5% level, ** 1% level.



Figs. 6 through 9. AC/A ratio plotted as a function of time for control subjects. Measurements based on accommodative response data with haploscope (H_R), accommodative stimulus data with haploscope (H_S), and accommodative stimulus data with a refractor using a Risley prism (P_S). Each circle represents the reciprocal of the slope of the straight line fitted by least squares to twenty data points over an accommodative range of 0 to 3.5 D.

came in for two or three additional trials; five of them also returned for several trials approximately one year later. Inspection of Table III shows that in twelve out of sixteen instances (eight subjects, two measures of the AC/A ratio) the average AC/A ratio immediately after orthoptics was greater than the AC/A ratio during the latter half of orthoptics (significant by sign test at 5 per cent level). The average increase in AC/A ratio for the interval immediately after orthoptics was 0.11 Δ/D. and 0.34 Δ/D. for the haploscope and refractor measures, respectively. The interpretation of this is that the increase in AC/A ratio observed during the orthoptic interval was maintained during the few weeks after cessation of orthoptics; moreover, in the majority of instances it presumably increased somewhat more.

Inspection of Table III shows that in eight out of ten instances there was a *decrease* in the average AC/A ratio one year later compared

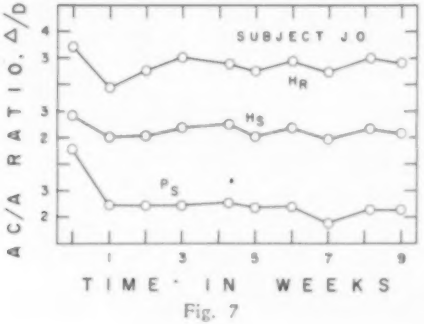


Fig. 7

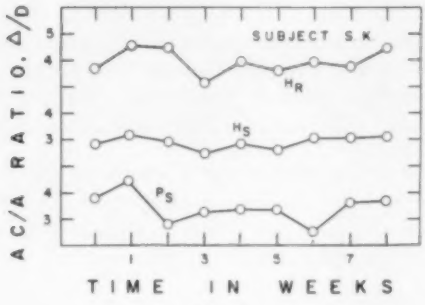


Fig. 8

to the average measurement immediately after orthoptics. This decrease was approximately 0.6 Δ for both the haploscope and refractor measures of the AC/A ratio, indicating a return of the AC/A ratio after one year toward its original value. Unfortunately, a good pre-orthoptic baseline for the AC/A ratio was not established, thus it is difficult to ascertain how the AC/A ratio one year after orthoptics compares with the *pre-orthoptic* AC/A ratio. In Figs. 3 through 5 it is seen that the first measure of the AC/A ratio one year after orthoptics is quite like the original pre-orthoptic value for three subjects (M.P., L.D., and R.K.) and somewhat lower than the original value for two subjects (J.L. and J.M.). It is curious how variable are the measurements of the AC/A ratio one year after orthoptics in comparison to measurements for the control subjects (Figs. 6 through 9). Whether this observed variability is in some way related to orthoptics or the binocular problems of these subjects is not known.

From an inspection of Figs. 2 through 5 one gets the impression of a relationship between the time plot of the AC/A ratio and the

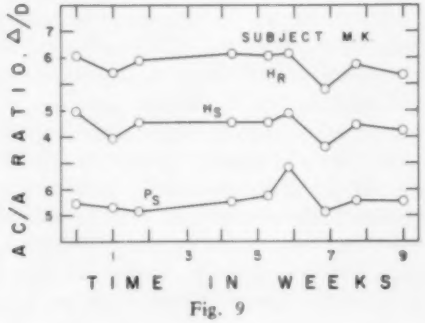


Fig. 9

positive relative convergence. This impression is supported by the fact that in all sixteen instances (eight subjects, two measures of the AC/A ratio) the rank correlation between AC/A ratio and positive relative convergence was positive (Table IV). Even though only five

TABLE IV

Rank correlation between positive relative convergence and AC/A ratio

Subject	N	Haploscope AC/A	Refractor AC/A
L.D.	11	+0.65*	+0.54*
R.K.	8	+0.62	+0.38
J.L.	14	+0.17	+0.45
J.M.	14	+0.59*	+0.19
M.P.	15	+0.08	+0.03
S.N.	14	+0.69**	+0.21
D.S.	11	+0.12	+0.55*
J.R.	11	+0.19	+0.43
M.A.	10	—0.11	+0.32
J.O.	10	—0.05	—0.44
S.K.	9	+0.50	+0.47
M.K.	9	+0.20	+0.05

* indicates significance at 5% level. ** at 1% level. Bottom four subjects are control subjects.

of the sixteen correlations were statistically significant, there is little doubt of a relationship in the experimental group between variation in AC/A ratio and variation in positive relative convergence since sixteen positive rank correlations might be expected by chance in an uncorrelated population less than once in a thousand times. In the control group there are five positive and three negative rank correlations, and none is significant.

Table V shows the rank correlation and mean difference between three measures of the AC/A ratio. Of the 36 correlations computed (twelve subjects, three measures of AC/A ratio), 31 are positive and eighteen of these are statistically significant. The haploscope response AC/A ratios and haploscope stimulus AC/A ratios are the most highly correlated (mean r_s about +0.79), and each is approximately equally correlated with the refractor AC/A ratios (mean r_s about +0.25). From Table V it is apparent that the haploscope response AC/A ratio is consistently greater than the haploscope stimulus AC/A ratio (average mean difference 1.2 Δ) and it is usually greater than the refractor AC/A ratio (average mean difference about 0.6 Δ). The refractor AC/A ratio tends to exceed the haploscope stimulus AC/A ratio by about 0.7 Δ. Taken together these data point up the fact that three measures of the AC/A ratio with different stimulus conditions result in different

TABLE V

Rank correlation (r_s) and mean difference (d) between haploscope response AC/A, haploscope stimulus AC/A, and refractor AC/A ratios

Subject	N		$H_R - H_S$	$H_R - R$	$H_S - R$
L.D.	12	r_s	+0.91**	+0.40*	+0.25
		d	+1.06*	+0.73	—0.33
R.K.	10	r_s	+0.84**	—0.27	—0.20
		d	+1.10**	+0.33	—0.77
J.L.	15	r_s	+0.88**	+0.48*	+0.65**
		d	+0.85*	—0.73	—1.58*
J.M.	15	r_s	+0.57*	+0.04	+0.45*
		d	+1.50	+1.37	—1.28
M.P.	15	r_s	+0.65**	+0.22	—0.08
		d	+1.15**	—0.15	—1.30
S.N.	14	r_s	+0.55*	+0.61*	+0.27
		d	+1.87*	+0.79	—1.08*
D.S.	10	r_s	+0.92**	+0.39	+0.49
		d	+0.93**	+0.56	—0.37
J.R.	13	r_s	+0.90**	+0.14	+0.18
		d	+1.76*	+2.53*	+0.77
M.A.	10	r_s	+0.67*	—0.08	—0.41
		d	+0.92**	+0.43	—0.49
J.O.	10	r_s	+0.85**	+0.21	+0.56*
		d	+0.47	+0.19	—0.28
S.K.	9	r_s	+0.83**	+0.18	+0.42
		d	+1.06**	+0.52	—0.54
M.K.	9	r_s	+0.87**	+0.53	+0.47
		d	+1.32**	+0.16	—1.16*
Average		r_s	+0.79	+0.24	+0.25
		d	+1.17**	+0.56**	+0.70**

* indicates significance at 5% level, ** 1% level. Average mean r_s computed by algebraically summing mean r_s values. Bottom four subjects are control subjects. Differences are in Δ/D.

values for the AC/A ratio, but these values tend to be positively correlated.

DISCUSSION

Earlier in the present paper certain questions were raised about the increase in AC/A ratio with orthoptic training found by Manas.[6] The results of the present investigation confirm Manas' finding of an increase in the AC/A ratio with orthoptics. A further conclusion from the present study is that the increase in AC/A ratio with orthoptics is probably genuine and cannot be attributed to practice effects, or to an increase in accommodative response or proximal convergence.

In summary, what is the evidence on which this conclusion is based? In each phase of the present experiment a control group of

subjects did not receive orthoptic training, but instead reported once a week for measurement of the AC/A ratio and positive relative convergence. If there was any practice effect operant it tended to produce a *decrease* in the AC/A ratio. For the control group of 24 subjects there was, after five weeks of testing, a small nonsignificant decrease of 0.08 Δ/D. in the AC/A ratio. For the control group of four subjects examined weekly over approximately a nine-week interval, one subject (J.O.) showed a decrease in the refractor measure of the AC/A ratio with successive trials (rank correlation —0.88), and six of the other seven correlations were also negative. There is no intention here to argue that weekly testing decreases the AC/A ratio but rather that the small individual changes observed are due to chance and that there is no evidence that testing causes an *increase* in the AC/A ratio.

For the 83 experimental subjects in Phase I of the present experiment the increase in the calculated AC/A ratio following orthoptics was statistically significant and amounted to 0.41 Δ/D. This increase resulted mainly from a larger decrease in the average exophoria at near (1.29 Δ) than at distance (0.36 Δ). Can this increase in AC/A ratio be attributed to an increase in accommodative response (and, hence, accommodative convergence) at near following orthoptics? In the absence of data on AC/A ratios based on accommodative response, this question would be difficult to answer. But, in Phase II of the present investigation the haploscope response AC/A ratios for eight subjects were followed during nine weeks of orthoptics and were found to increase by an average of 0.66 Δ/D. This increase in AC/A ratio cannot be attributed to an increase in accommodative response following orthoptics. It is interesting that the average refractor AC/A ratio for these same eight subjects increased by only 0.32 Δ/D. (Table III, significant by t-test at 1 per cent level).

It has been reported that an increase in convergence of the eyes can be brought about by moving the target toward the eyes[10-12] or by increasing the size of the target.[13] In Phase II of the present experiment a Badal optometer was centered before the right eye in conjunction with a haploscope. Thus, as the stimulus to accommodation was increased by moving the test chart toward the optometer lens, there was no substantial change in perceived size or distance apparent to the subject. Because of this experimental procedure it is not likely that the observed changes in the haploscopic measurements of the AC/A ratio resulted from changes in proximal convergence.

What about the permanency of the changes in AC/A ratio brought about by orthoptics? For a few weeks after orthoptics was discontinued

the AC/A ratios seemed to maintain their higher values, and in some instances there was apparently a further increase. About one year later, however, the AC/A ratios appeared to have decreased and approximated the original values. The suggestion here is that the observed increase in AC/A ratio with orthoptics was not permanent. It is noteworthy that the AC/A ratios showed considerable variability one year after orthoptics. There was no attempt in the present study to see how little additional orthoptics would be required to promote an increase in the AC/A ratio to the original post-orthoptic value.

There are at least two possible interpretations for the positive correlation between AC/A ratio and positive relative convergence. On the assumption of no interaction between these two "kinds" of convergence, a positive correlation could result if both responded separately to orthoptic treatment. Accommodative convergence and relative convergence would each be correlated with time, and hence they would be correlated with each other. An equally valid interpretation is based on the assumption of interaction between accommodative convergence and positive relative convergence. If the principal effect of orthoptics was to increase one kind of convergence (say, positive relative convergence), then by virtue of an interaction with the other kind of convergence (say, accommodative convergence) it might also increase. The post-orthoptic decline in one kind of convergence would result in a corresponding decrease in the other. There is no evidence from the present study to support either interpretation. It may be worth commenting on the lack of evidence for complete independence of the various "components of convergence." On the other hand, there is some evidence of an interaction between accommodative, proximal, and fusional convergence.[10, 14]

Finally, the fact that the same conclusions obtain whether the haploscope or refractor AC/A ratios are used implies that the observed increases in AC/A ratio with orthoptics are genuine and not the result of a particular psycho-physical method of measurement.

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ANNOUNCEMENT

FIRST A.O.A. INTERNATIONAL SYMPOSIUM ON CONTACT LENSES

"Scientific knowledge is characterized by its accumulative nature," stated Dr. Melvin B. Dunbar, Lebanon, New Hampshire, newly appointed Director of the American Optometric Association's Department of Education as he announced the Department's plans for two Symposia to be conducted during 1961.

The First International Symposium on Contact Lenses will be conducted at the Illinois College of Optometry, Chicago, on January 22-23, 1961. A Symposium on Visual Training is tentatively scheduled for early Spring.

"The purpose of the Symposium is the dissemination of Optometry's knowledge in the field of contact lenses." Dr. Dunbar announced. "The Department will continue to assist State Associations in the conduct of postgraduate institutes such as held by the Department during the past few years. However, we believe we should also concentrate our attention on meetings which will result in important papers of value to the entire profession. For example, papers from the Symposium on Contact Lenses will be published in book form and be available to scientific journals, newspapers and magazines, as well as other channels of public information and the profession itself." Attendance at the First International Symposium on Contact Lenses will be by invitation only.

JESSE RAMSDEN: INVENTOR OF THE OPHTHALMOMETER*

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Credit for the invention of the ophthalmometer appears to be given most often to Helmholtz[1, 2, 3, 4] (1866) although several authors[5, 6, 7] attribute the original principle to Thomas Young (1801). Apparently unnoted is an instrument which employed the essential components of our modern ophthalmometer, used for corneal measurements by Jesse Ramsden before the publications of Helmholtz or Young. The construction of this instrument and the experiments for which it was designed are the subject of this paper.

In order to establish the inventor of the ophthalmometer it is expedient to define the technique of ophthalmometry and the instrument.

Ophthalmometry refers to a method of determining corneal curvature by measuring the image formed on the cornea, which acts as a convex mirror, from an object of known size and position. The radius of curvature of the cornea may then be determined from optical laws regarding magnification by a convex spherical mirror.

The ophthalmometer consists of an object of known size, namely the distance between luminous mires, and a device by which the corneal image of the distance between mires may be measured accurately. The measurement depends primarily upon a doubling apparatus, which, together with a telescope may be considered the essential components of the instrument.**

Early investigators who contributed to the development of the ophthalmometer were confronted with two problems. The image to be measured was very small and the eye constantly made tiny involuntary movements even though the subject tried to maintain steady fixation.

The problem of observing a small image was solved by using a telescope. Helmholtz,[8] in 1866, credits Kohlrausch with the design of a simple type of ophthalmometer in which the corneal image of two

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**For explanation of the optics of the ophthalmometer see references 5, 6, and 7.

luminous points was viewed by means of a telescope. Kohlrausch had two adjustable hairlines mounted in the focal plane of the objective which he could position at the image of the points. He then substituted a ruler in the former eye position of the subject and determined the separation of the micrometer hairs on the telescopic image of the ruler. The value of this measurement represented the corneal image size.

Helmholtz modified the ophthalmometer of Kohlrausch by adding a doubling device and thereby completed the basic design of the instrument as it is today. Because his doubling device greatly increased the accuracy of the ophthalmometer existing thereto, and because he published considerable data on the curvature and contour of the cornea, Helmholtz was often given credit for the invention of the ophthalmometer. Helmholtz apparently overlooked other ophthalmometer designs which had been reported in the English literature.

Ramsden constructed his ophthalmometer during the latter part of the eighteenth century, a time when the principal interest of natural philosophers was to determine the nature of the accommodative process. Everard Home and Jesse Ramsden, in collaboration, postulated that a steepening in corneal curvature was responsible for the refractive power change during accommodation.[10] Ramsden, an optician, designed two instruments for testing the validity of their hypothesis.

The first apparatus contained a head support, a fixation device, and a short-focus telescope. The telescope was placed perpendicular to the line of sight and directed at the corneal apex so that movements of the cornea along the line of sight could be measured by a micrometer eyepiece. From experiments with this instrument, Home and Ramsden concluded that changes in corneal curvature occurred and that the cornea was the seat of accommodation. It is likely that this experiment was contaminated by either head movements or involuntary ocular excursions.

A year later, Home and Ramsden abandoned the original apparatus and for it substituted a new instrument designed by Ramsden in which he applied the principle of doubling the corneal image and observing it through a telescope. He thereby constructed the first ophthalmometer which employed the same components as our modern instruments.

In 1796, Home credited the construction of this instrument to Ramsden in the following statement before the Royal Society of London.

> It readily suggests itself, that if the convexity of the cornea was increased to a certain degree, it could be measured by means of an image reflected from its surface, and viewed in an achromatic microscope, with a divided eye-glass micrometer. To ascertain whether the quantity of increase of the convexity of the cornea, in the adjustment of the eye, could in this way be ascertained, the following experiments were contrived, and made by Mr. Ramsden. Our former experiments had sufficiently proved the

unsteadiness of the human eye; the first trials on the present occasion were therefore made on convex mirrors, as these artificial corneas could be more readily managed, and such previous experiments would enable us to apply the same instruments with more facility to the eye itself.

Two convex mirrors, one 4/10 of an inch focus, the other 5/10, had their flat surfaces made rough, and blacked, to prevent an image from being seen from both surfaces, which was found to be the case when this precaution was omitted. One of these mirrors was stuck on a piece of wood directly opposite to a window, at 12 feet distance from it; a board 3 feet long and 6 inches broad was placed perpendicularly against the sash of the window, and its image reflected from the mirror on the object-glass of an achromatic microscope, with a divided eye-glass micrometer. The two images were separated by means of the divided eye-glass, till their surface of contact, which appears like a black line, was rendered as small as possible. When this effect was produced on the images from the mirror of 4/10 of an inch focus, that mirror was removed, and the other put in its place: the contact of the two images, which before appeared like a line, had now acquired considerable breadth: corresponding exactly to the difference between the convexities of the mirrors.

Ramsden was unable to determine any change in corneal curvature during accommodation with his ophthalmometer: consequently, he attempted to determine the amount of change which could occur at the cornea without his detection in order to measure the accuracy of his instrument.

For this purpose two mirrors were ground, and prepared in the same way as though used in the preceding experiment: their radii were exactly ascertained by measuring the tools in which they were finished off: the one was 4/10 of an inch focus, the other 403/1000, the difference between the size of the images reflected from their surface was just visible in the micrometer.[10]

Ramsden reasoned that involuntary movements would make it impossible to duplicate the accuracy on an eye that he obtained when measuring the mirrors. Indeed, it would have been difficult to match this accuracy, for the mirrors measured had radii of 10.16 mm. and 10.23 mm., representing 0.25 D. difference.

After completing this experiment, Home and Ramsden discarded their hypothesis that the cornea was the seat of accommodation and then asserted that accommodation took place by simultaneous changes in the cornea, axial length, and crystalline lens.

Ramsden and Home used their ophthalmometer to detect changes in the corneal curvature and were less concerned with the actual value of the corneal curvature, no figures being reported. That their instrument was capable of direct measurement of the curvature is evident in the final sentence of the first quotation, which states that the separation of the images corresponded to the difference between the curvatures of the two mirrors which were measured. It is logical that Ramsden's eyepiece in the ophthalmometer was capable of measurement since this was merely an adaptation of the same device he had previously used in telescopes for astronomy. Ramsden's eyepiece micrometer was a modification of pre-existing doubling systems which, even at that early date,

Figure 1. From Ramsden, Fig. 4

had undergone a number of improvements and modifications.

The first doubling system was invented by Sirvington Savery, an astronomer, in 1743, and was used in a Heliometer.[11] In all, Sirvington described three doubling systems, none of which contained a device to alter the separation of the images but which functioned by measuring the distance between images with a micrometer similar to a traveling microscope.

Following Savery, several adaptations were made in the method by which the doubling in the Heliometer was produced. Pierre Bouguer,[12] in 1748, mounted lenses of equal focal length so that one could be moved while the other remained stationary, thereby producing the first doubling system with a method of adjusting the images. John Dolland,[13] 1754, cut the object glass of a telescope along a diameter and mounted the hemicircular halves of the lens so they could be moved in opposite directions along their division. In 1777, Nevil Maskelyne[14] placed a glass prism before the objective to divert a portion of the light entering the telescope, a method of doubling now used in contemporary keratometers.

In 1779, Ramsden designed a modified doubling system, the split eyepiece micrometer, which is the same design he later used in his keratometer.[15] The drawings by Ramsden which accompanied his article are reproduced in Figure 1. Explanations of the figures follow:

Fig. 4 represents the glasses of a refracting telescope: xy the principal pencil of rays from the object—glass o: tt and uu the axes of 2 oblique pencils: a the 1st eye-glass: m its conjugate focus, or the place of the micrometer: b the 2d eye-glass, c the 3d, and d the 4th, or that which is nearest the eye. Let p be the diameter of the object-glass, e the diameter of a pencil at m, and f the diameter of the pencil at the eye: it is evident, that the axis of the pencils from every part of the image will cross each other at the point m: and e, the width of the micrometer-glass, is to p the diameter of the object-glass, as m a is to g o, which is the proportion of the magnifying power at the point m: and the error caused by an imperfection in the micrometer-glass placed at m, will be to the error had the micrometer been at o, as m is to p.

Fig. 3d represents the micrometer: A a convex or concave lens, divided into two equal parts by a plane across its centre: one of these semi-lenses is fixed in a frame B, and the other in a frame E, which two frames slide on a plate H, and are pressed against it by thin plates aa: the frames B and E are moved in contrary directions by turning the button D: L is a scale of equal parts on the frame B: it is numbered from each end toward the middle with 10, 20, &c. There are two verniers on the frame E, one at M, and the other at N, for the conveniency of measuring the diameter of a planet, &c. On both sides of the zero. The first division, on both these verniers, coincides the same time with two zeros on the scale L, and, if the frame is moved towards the right, the relative motion of the two frames is shown on the scale L by

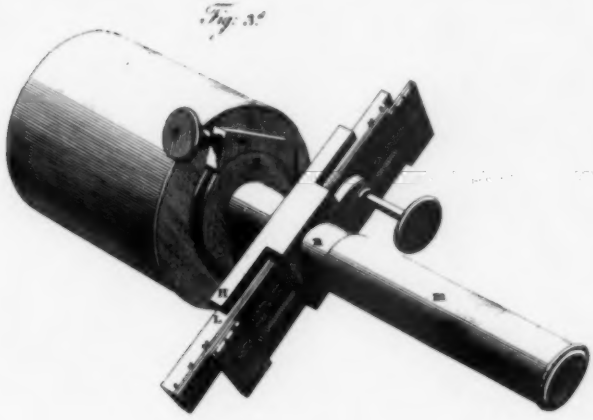

Figure 2. From Ramsden, Fig. 3d

the vernier M: but if the frame B be moved towards the left, the relative motion is shown by the vernier N.

This micrometer has a motion round the axis of vision, for the conveniency of measuring the diameter of a planet, &c. in any direction, by turning an endless screw F, and the inclination of the diameter measured with the horizon is shown on the circle g, by a vernier on the plate V. The telescope may be adjusted to distinct vision by means of an adjusting screw, which moves the whole tube with the micrometer nearer to or farther from the object-glass, as telescopes are generally made; or the same effect may be produced in a better manner, without moving the micrometer, by sliding the part of the eye tube m on the part n, by help of a screw or pinion.

After Ramsden invented his micrometer other astronomers introdduced various types of doubling systems. Of interest among these was the method of Thomas Clausen[16] in which he produced doubling by two parallel plates of glass oriented at equal angles to the optical axis of the telescope. This device is particularly interesting as it appears to be the prototype of the doubling system constructed by Helmholtz, 15 years later, with the exception that for measurements with Clausen's instrument only one plate was rotated while in the doubling system of Helmholtz both plates turned equal amounts.

SUMMARY

An ophthalmometer consists of three essential components, an object, a magnifying device, and a doubling system. The first instrument which combined these components was invented by Jesse Ramsden in 1796. It contained a board against a window for an object, a short focus telescope for a magnifying device, and a split lens micrometer for a doubling system. This instrument had an accuracy of 0.25 D. as determined from polished mirrors.

Ramsden received little acknowledgement for his ophthalmometer because it was constructed to detect corneal changes during accommodation, an experiment of practically no interest after the classic work on accommodation by Thomas Young in 1801.

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INTERPROFESSIONAL RELATIONS

Over the years the subject of interprofessional relations has been touched upon by the writer in his annual report to the members of the Academy.* As a professional group, optometrists have watched the ebb and flow of official professional cooperation with more than casual interest as the extent of such cooperation has some bearing upon the rapidity of future continued development in the art and science of refraction. It is said that two heads are better than one and on that basis the Academy has worked towards an evermore harmonious working relationship with medicine with the ultimate best interests of the public in mind.

What has been the trend during the past year? Are the relationships between optometry and medicine improving or have they deteriorated? Is the cold war now being waged against optometry by cer-

*Carel C. Koch. Excerpts from the Annual Report of the Secretary, American Academy of Optometry. San Francisco, California, December 10, 1960.

tain minor though vocal elements of ophthalmology, aided by some dispensing opticians, getting worse, or have their programs decreased in number and intensity?

There is, the writer believes, a decided trend among our friends in ophthalmology to downgrade these attacks upon optometry. Many ophthalmologists never supported these programs and privately deplored their actions. These men realize the capabilities of optometrists and are distressed in finding themselves apparently part of an unjust mud slinging campaign which they feel will in time only injure the standing of all eye men in the minds of the public. This group while not at present openly vocal in ophthalmological politics deplores the current action of their colleagues.

On the other hand, pressures from those who are leading the fight against optometry have succeeded in continuing the present non-cooperative attitude of the American Medical Association. An attitude which must be altered before the cold war ends. We in optometry regret that these ophthalmologists, active in the politics of the A.M.A. have been able to have their own way when it is widely admitted that the majority of physicians have no animosity towards optometry. In fact the reverse is true as many of these physicians and their families are patients of optometrists and close friends as well. What is the answer to this problem? The leadership of the A.M.A. should and must correct this mistake and reestablish the friendly position of a decade ago between medicine and optometry. It is only by taking this action that the cold war that now exists can be brought to a close.

Is there any immediate prospect that this will take place? The writer is not in a position to judge this, but it is known that discussions in high places have been had during the year in which the subject was brought up in a way which indicated that some strong support might be forthcoming from those in medicine who preferred constructive to destructive action. So much for the medical side of this problem.

Now as to optometry and her position in this matter. Has there been any substantial change in attitude or programming in relation to this attack upon the profession. From the standpoint of the Academy there has been no change. The policy of the Academy has been one of regret that the A.M.A. moved as it did several years ago and the Academy's official position has been to do everything possible to secure a reconsideration of the matter, keeping uppermost in mind the independence of optometry as a profession and the need for integrity and honesty in our dealings with medicine. To a very considerable degree the position of the American Optometric Association is similar and

optometry presents an official united front against the present A.M.A. stand. The president of the A.O.A. is expected to speak to the Academy during the meeting in San Francisco and he may further discuss this matter from an organizational standpoint.

Optometrists in general and Academy members in particular are proud of their scientific and clinical contributions to this field. Any even casual study of the professional literature of the past half century will show that optometric contributions have been many and that these have been widely accepted by all workers in the refractive eye field. The basic research work constantly carried on in our educational institutions in clinical refraction; the physiology of vision; physiological optics; the optics of spectacle lenses and more lately contact lens fitting is second to none and is recognized by educators, practitioners and scientists for its value to both optometry, ophthalmology, opticianry and science in general.

As these things are true we find an evidence of a developing feeling of resentment among optometrists caused by the unjust criticism levelled at them by elements of ophthalmology in the current cold war. While the general volume of optometric practice has never been higher optometrists still resent the fact that a great organization such as the A.M.A. can be duped into following a position lacking merit by a small group of militant ophthalmologists. This attitude on the part of the men in practice is becoming more pronounced and unless this is altered it will in time change the friendly feeling of optometrists towards medicine. As the profession has always staunchly supported medicine this change would be cause for regret.

CAREL C. KOCH

CHRISTMAS GREETINGS

The officers of the Academy and the staff of this publication wish all of our members and readers the best holiday season possible. The year just ending has been a fine one for optometry. We face the future with confidence and at this time we express to optometrists everywhere the Season's greetings and our wish for the best of all good things in 1961.

THE EDITORIAL STAFF

SPECIAL REPORT

WHERE WE STAND ON CONTACT LENS FITTING IN 1960*

John W. Hier†
Minneapolis, Minnesota

In this year 1960 more contact lenses will be prescribed and fitted than in any previous year. There are very few inventions which have required as much effort, ingenuity, money, and just plain dedicated research, and very few inventions which have developed as a result of so many persons in private practice and in laboratories chipping away with but one goal in mind, a contact lens which could be worn all ones waking hours in comfort and safety. We have now, in most cases, achieved this state of success, but analogous to the young man in a dark restaurant who wished to attract the young lady across the room, it was necessary to turn on a light. The best state of contact lens perfection could exist but unless the public was educated to the fact, not many people would benefit. The profession could not advertise but one or two contact lens manufacturers did so. One in particular has waged a never ending campaign directed to the public, and thus has done in a very few years what might otherwise have taken twelve or fifteen years. Some say, "Well, they did it for selfish reasons, to sell lenses." Their reasoning is unimportant. The fact that they did it benefitted every serious practitioner. In addition the finest contact lens could be available and the best public information campaign waged, but if the persons requiring contact lenses had no money, the whole advancement we have known could have collapsed or at least have been seriously retarded. During the past few years more Americans have enjoyed a higher level of prosperity than in any similar period!

In this year 1960 more contact lenses will be "sold" than in any previous year. Any time something involving such a sum of money catches the fancy of the public, hucksters and merchants of sorts will do what they can to reap some of the financial harvest. Ethics, welfare of the public, and common decency have no influence upon their standards and so the public falls easy prey to these merchants of deceit. One has but to turn the pages of any metropolitan newspaper to see that these op-

*Read before the Contact Lens Association for Optometry meeting at the Pick-Nicollet Hotel, Minneapolis, August 21, 1960. For publication in the December, 1960 issue of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.

†Optometrist. Fellow, American Academy of Optometry.

portunists have invaded and are trying to usurp an area of public service developed by dedicated men.

In this year 1960 more and better techniques will be used than in any previous year. Along with the development of todays contact lenses, techniques have been improved and new ones found, allowing the present day practitioner to do more skillful work than was heretofore possible. Instruments have been and are being improved and developed to bolster this skill, not only in fitting, but in checking accuracy of lenses obtained from the laboratory. Physiological and anatomical studies have been and are uncovering secrets not before known. Most practitioners are familiar with Bier's studies of corneal topography and the American modification of this which is the basis of most fitting techniques in the optometric office 1960. All this came through the tireless efforts of many people dedicated to perfect contact lenses.

In this year 1960 more less desirable techniques will be used than in any previous year. Even though organized optometry has been and is doing a splendid job of incorporating new advancements into practice, there are those who through laziness, incompetence, and determination to do quick, low fee fitting, are using methods which violate the rules of good refractive procedure in order to dispense contact lenses at a quick profit and with little effort made to study the physiological fit as long as the patient does not complain. This type of practitioner has "no time" for postgraduate study and feels no obligation to support his professional associations which help him in so many ways.

In this year 1960 more accurate, ethical, and truly informative material on contact lenses will be released to the public than in previous year. Due to the successes in contact lens development, optometry has a wonderfully exciting story to tell as witnessed by the fact that many high myopes and hyperopes can now attain vision superior in distortion-free-quality to that of spectacles: the fact that patients with irregular astigmatism can in most cases receive acuity not possible with spectacles: the fact that post cataract patients can substitute a relatively thin disc of plastic for a heavy spectacle lens whose peripheral distortions leave much to be desired: the fact that the subnormal vision case can, in many instances, through contact lenses or a combination of contact lenses and telescopic systems be aided in a manner not heretofore possible; and the fact that young children developing towards myopia now have hope that an early adaptation to contact lenses may alter its progression or impede its progress.

In this year 1960 more inaccurate, unethical, and truly non-informative material on contact lenses will be released to the public

than in any previous year. Men, who for the sake of a few pieces of silver or with enthusiasm outweighing common sense, feed the public with false hopes based on misleading claims. They are similar to those who promise cancer cures, get rich schemes and the like! Those who claim: "Wear contact lenses all day the first day"; "You too can be fitted"; "Lifetime 'guarantee'" "Finest brand made"; "This is before, this is after," are the ones who serve the cause of the huckster.

In this year 1960 more persons than in any previous year will have reason to bless the day they were introduced to contact lenses. These are the happy patients who are fortunate to select a conscientious, ethical and professional practitioner whose prime concern is the patient's welfare. This is the practitioner who continues to study, who always updates office techniques and who uses only top quality materials in his office, a man who would rather lose a prospective patient than make misleading statements.

In this year 1960 more persons than in any previous year will have reason to curse the day they were introduced to contact lenses. These are the persons who are looking for a "bargain," the persons who still believe the world is giving things away for nothing. They haven't heard the time honored phrase (or choose to ignore it) "You get exactly what you pay for." These are the persons who think all contact lens practitioners are licensed doctors with schooling commensurate to the task. These patients eventually not only lose confidence in the man who fitted them but also reflect this same attitude toward the contact lens field in general. And these people talk. One disgruntled patient can do more harm than the good wrought by many satisfied patients. Here, it might be added, is a situation where the profession must shoulder much of the blame. Somehow it hasn't put forth the right kind of effort to inform the public about certain aspects of this problem. Perhaps it has been afraid that honest, straight forward persuasion will be regarded with suspicion.

Historically, the original contact lenses were developed by physicians and opticians in an effort to protect the cornea from a diseased lid. Another use was later realized, namely, that of incorporating optics into the shell—hence the contact lens. Opticianry, represented by Zeiss and other firms, contributed know how. As the years passed improvements were made by optometry and its forerunner, refractive opticianry. The development of contact lenses, as seen today, is a mixture of contributions from varied sources. As a result, three groups of persons are currently engaged in fitting contact lenses. Two groups are professional people, namely, optometry and ophthalmology; the third

is a lay group functioning as technicians.

Based on undergraduate training and philosophy, professional optometry is, of the professions, uniquely qualified to practice contact lens fitting and prescribing. With proper studies in anatomy, physiology, pathology, neurology and optics, the modern graduate enters practice qualified to practice this particularly interesting phase of optometry. It is doubtful that one could name any major change in fitting and production techniques that was not at least in part the brain child of an optometrist. The literature is rich in documentation of this. As a profession, medicine has seemed skeptical, and in most cases, definitely indifferent towards the fitting of a contact lens. For this reason, during the hard years when failure was the rule rather than the exception, individual optometrists were bearing the financial losses and the personal sting of having to admit that this idea did not work or that that technique would not bring forth results. Private offices became laboratories. These were indeed the years when, with an almost fanatical zeal, men of optometry pushed forward with but one thought and one desire. Indeed! Optometry bore it almost alone!

From the practical point of view, ophthalmology does an infinitesimal amount of the contact lens work currently being done. From the standpoint of anatomy, physiology and neurology, the ophthalmologist certainly qualifies as a contact lens practitioner. From the optical and fitting standpoint, however, much is lacking as they have shown little interest in these matters.

The technician fitting contact lenses represents a strange mutation springing from the development of contact lens fitting. He is not, as a rule, a professional man. He usually possesses no undergraduate or graduate degree in visual care or allied ocular work. He holds no license and has therefore no code of ethics to live up to; has no board of examiners to investigate his qualifications and therefore can not be held accountable to anyone or anything. The technician is not allowed by law to refract or in any way to carry on a visual examination. Yet these same optometry laws are, it seems in most states, powerless to prevent an unlicensed, nonprofessional person from fitting a contact lens, a process requiring a great intimacy with the human eye. Yet week after week, month after month and year after year those who practice observe the law being flounted by technicians. One has every right to ask why something is not done about this and why those charged with the public welfare sit idly by as the public is taken advantage of.

If it were not for the support of medicine and, in some cases, optometry, regrettably, this group could not survive. The ophthalmolo-

gist who refracts a patient, writes his findings on a prescription and refers the person to a contact lens technician is doing much the same as a general practitioner of medicine might do who does a physical examination, writes the findings on a paper and sends the patient to a pharmacist to decide on the final drugs and dosages after the physician has suggested only one element of the compound drug to be used. Of course no physician would do this. Why, then, is it done with contact lenses? It is done because it is expedient. The technician is not engaged in an economic rivalry with the ophthalmologist, so what solution could be simpler? Happily, the optometrist who does this sort of thing is rare. Yet occasionally optometrists do send contact lens patients to a technician. All this in spite of the fact that excellent optometric contact lens men maintain offices in their vicinity. If optometrists refuse to refer patients requiring a service they do not render to other optometrists who do, how can they expect practitioners in other professions to refer patients to optometrists? The practitioners are merely following the example thus established. In areas such as this, optometry can be its own worst enemy!

In evaluating the situation 1960, this writer believes enlightened but firm action must be taken in three areas.

1. Legislation. Optometry laws vary greatly between these United States and yet professional optometric thinking does not exhibit such geographic differences. Uniformity of optometric laws without infringing upon states' rights is a goal toward which optometry should work unceasingly. It is not the writer's intent that all state optometry laws should be copies of the others, but certainly they should have one basic point in common—protecting the public from nonlicensed, improperly schooled persons. Dental laws prevent unlicensed persons from fitting dentures; why should unlicensed persons be allowed to adapt a contact lens to the human eye where the consequences of a poor fit are infinitely more grave? It has been said that many states actually have good optometry laws but due to oversight caused by the clamor toward attempted enactment of new legislation, much real progress has been thwarted.

The writer suggests that a meeting be held between legal representatives of as many states as possible and the legal talent of the American Optometric Association. An analysis should be made of the laws already on the books and of how they may be best used. Legal action deemed necessary should then be instituted in the states where laws are most favorable; chances of winning would be greatest in these states and the success obtained would, of course, set a precedent for

legal and/or legislative action in the states where current optometry laws are weak in this particular. Individual optometrists should always be looking for the opportunity to inform state legislatures of the need for specific legislation.

2. Education. Approximately ten years ago several contact lens manufacturers began giving short courses (three to twelve hours) in contact lens fitting techniques. Some were given at the home office, but most were given by traveling representatives, usually optometrists, who held meetings in hotel rooms of the larger cities. Naturally the context was slanted toward the beliefs of the particular company represented at the meeting. The more lectures were given, the more practitioners began fitting. The more men fitting, the more demand for lenses; hence the motivating force for these courses was the economic factor. Be that as it may, some of todays leading contact lens practitioners were developed in these smoke filled meeting rooms. These courses were necessary and good because they then filled a void not adequately filled by the schools of optometry. During this period, new ideas and techniques were born in the laboratories, not in the schools.

Certainly now the schools of optometry are to be commended for their current high calibre contact lens instruction and research programs. Nowhere else are such complete studies available. Here anatomy, physiology, neurology and optics are studied and evaluated to determine their relationships to contact lens adaptation and the numerous rammifications thereof. These courses are available on a graduate level also, and in this writer's opinion, fulfill the need, whether for refresher or more basic concepts.

The need for the manufacturer type course has passed except as it relates to new and advanced developments in lens design and application. The results of the continuation of the former type course can only be "training" greater numbers of technicians and older optometrists not possessing credits in undergraduate contact lens work and too indifferent to return to school. As long as the manufacturers continue in this manner this problem will exist, to the detriment of the public whom the profession serves. If a practitioner wants the fees inherent in a good contact lens practice, he should be willing to pay the price in proper post-graduate education.

3. Public Relations. The professional practitioner, of course, can do no advertising. He must rely on word of mouth from one satisfied patient to a prospective patient. He must rely on a good public image of his profession. The writer believes more institutional advertising of a public service nature must be done on a national, state, and city and/or

county level. Not only the qualifications and educational background of the optometrist but the advantages and advances in lens design and application must be told. If organized, ethical optometry does not tell the story the public will get only distortions and half truths.

In this report the writer has attempted to take a long, hard look at the contact lens situation as it appears to him in 1960. There are many good things about it, but many things are far from desirable. The writer believes that the technician, when properly trained and closely supervised, has a most proper place in the scheme of things and so previous references refer to that group of technicians who do not have and do not want such supervision and/or training.

Neither legislation, education nor public relations individually represent the full answer to the problems faced, but each in its own way is necessary. Legislation is not enough because laws cannot instill ethics and professional honesty in men's hearts: but good laws can limit outward abuses to the public. Education is also not enough because at times it falls on deaf ears; but, in many instances, it will change a man's ways by giving him an enlightened spirit that will do the right thing, law or no law.

Because any battle that now rages or ever will rage between professional and nonprofessional groups is ultimately won or lost in the arena of public opinion, good public relations are vital. Information must always be factual, clearly spelled out and uncluttered by catch phrases, false promises or hints of promises. The American people have been fooled at times, but eventually they can be relied upon to support the right approach if the case is properly stated. Obviously public relations is not the only answer and therefore all three approaches are required: legislation, education and public relations.

As one can readily see, the future depends on many variables. Some can be controlled and others perhaps not completely, but to a large extent, at least, it lies in our hands. Here we stand 1960!

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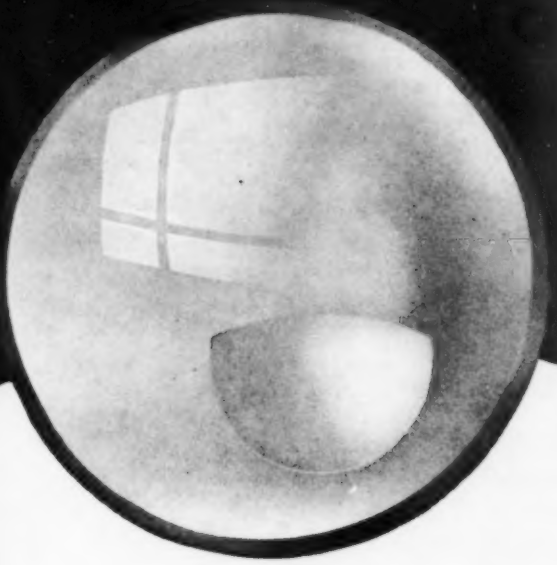

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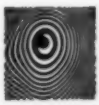

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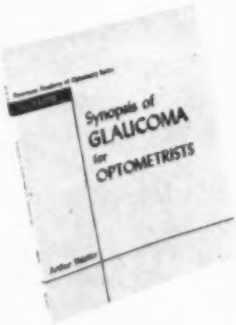

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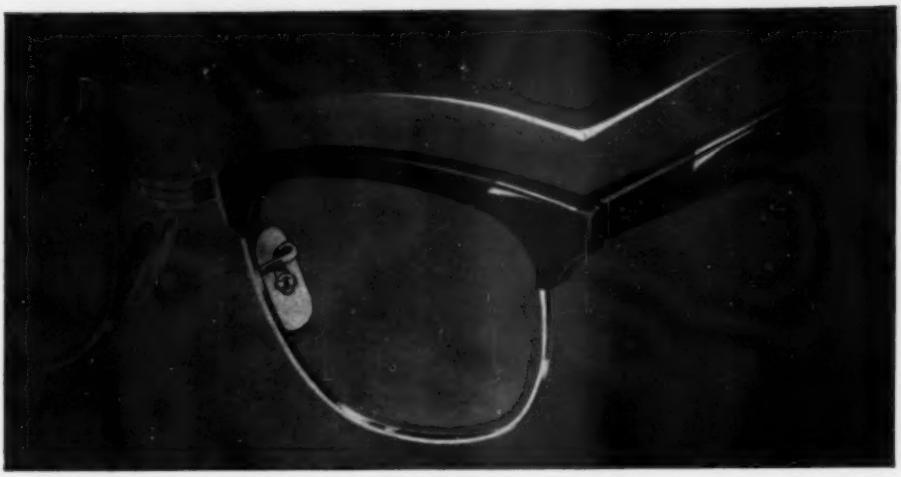

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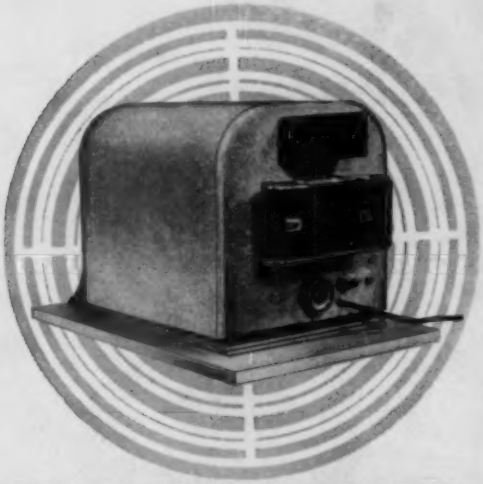

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